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ORIGINAL ARTICLES.

I.—Eminent Living Geologists.

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(WITH A PORTRAIT, PLATE IX.)

THE name of Geikie has become as familar to present-day geologists as those of Murchison, of Sedgwick, or of Lyell were to our immediate predecessors.

Notices and portraits of his elder brother, Sir Archibald Geikie, K.C.B., the President of the Royal Society, have already appeared in the Geological Magazine (see Vol. for 1890, Pl. II, pp. 49–51, and 1907, Pl. I, pp. 1–2); it is high time to present that of the younger brother, Professor James Geikie, who occupies the leading place in our science and in geography in Edinburgh and its University, and is known everywhere also by his published works, especially by his contributions to Glacial Geology.

James Geikie was born in Edinburgh August 23, 1839, and after being educated at the High School and the University of his native city, he entered the Geological Survey in 1861, and became a District Surveyor in 1869.

"In those early days," writes James Geikie, "when I joined the Geological Survey in Scotland, the Survey maps showed only the 'solid geology'; the loose superficial deposits known generally as 'drift' were entirely ignored. It was then decided that the 'drift' should henceforth be mapped, and thus my earliest years on the Survey were spent in re-surveying ground which had already been mapped so far as the solid geology was concerned, my work being confined to the insertion on the field-maps of the so-called 'drift' and peat. From the first, therefore, I became interested in our 'superficial formations', more especially in the Boulder-clay and the gravels and sands associated with it. My interest in these deposits, however, dates much further back—in fact, to my school days; so that I did not come to the Survey quite a greenhorn so far as the drifts were concerned.

"Later on, while mapping in the Southern Uplands, the peat-bogs, with their remains of trees, arrested my attention, and seemed to suggest that the explanation of the phenomena then in vogue was insufficient. Accordingly my holidays for a few years were spent in the Highlands and Outer Hebrides, for the purpose of increasing my

knowledge, not only of peat, but of 'superficial formations' generally. Eventually I reached the conclusion that the phenomena of the peat bore witness to a succession of climatic changes, and my views were communicated to the Royal Society of Edinburgh in a paper 'On the Buried Forests and Peat-mosses of Scotland, and the changes of climate which they indicate'[1] (1866).

"I have, since then, considerably extended my acquaintance with the peat-bogs of Scotland and other lands, but have found no reason to change or modify the general conclusions I arrived at so long ago —conclusions which have been of late years strongly supported by Dr. Lewis, whose researches into the botanical history of the peat-mosses seem to me to mark a distinct advance in our knowledge of Pleistocene geology."

Dr. James Geikie's survey work in succeeding years lay chiefly in the Lowlands, and the bordering tracts of the Southern Uplands and Highlands. He had thus to map considerable areas of Silurian, Old Red Sandstone, and Carboniferous, together with large tracts of the associated igneous rocks. This 'solid geology' was sufficiently engrossing, but the glacial phenomena had certainly the greater fascination for him, and most of his holidays were devoted to the study of these phenomena either in this country or on the Continent. Having arrived at certain conclusions as to the climatic changes of Pleistocene times, he broached these views in the GEOLOGICAL MAGAZINE (1871–2) in a series of papers "On Changes of Climate during the Glacial Epoch". These papers formed the germ of James Geikie's *Great Ice Age*, issued in 1874, a second edition of which appeared three years later. His *Prehistoric Europe*, published in 1882, was really a supplement to that edition, while the third edition of the *Great Ice Age* (1894) embodied the further results obtained by assiduous study of the work done by others, and by the devotion of his holidays to research in this country and abroad.

Having been appointed (1882) to the Chair of Geology at Edinburgh, many new interests claimed his attention. His pupils having complained that the textbooks of geology then available were either too meagre or too elaborate for their purpose, Professor Geikie was induced to prepare an 'intermediate' textbook (*Outlines of Geology*) which was issued in 1884, a fourth edition being called for in 1903. He also set himself the task of improving the teaching of geography in schools. The kind of geography taught at that time and the textbooks in common use were dry and forbidding, and one had no difficulty in proving that such was the case. But James Geikie was only one of a number of ardent reformers, who in 1884 united to form a Scottish Geographical Society, which has succeeded beyond their utmost expectations, and has played no small part in effecting a complete revision of the mediaeval system of teaching geography in the Scottish schools, and in getting lectureships on the subject established in the universities. Dr. James Geikie was elected president in 1904, but after holding office for six years his constantly increasing work at the University compelled him to resign. On his retirement

[1] See GEOL. MAG., 1867, pp. 20–3, and Roy. Soc. Edinb., vol. xxiv, pt. ii, pp. 363–84.

the Council awarded him the gold medal of the Society, and invited him to have his portrait painted for the Society's hall. Professor James Geikie has for many years acted as Honorary Editor of the Society's organ, the *Scottish Geographical Magazine*, one of the best scientific journals extant.

His long connexion with the Royal Scottish Geographical Society induced him frequently to bring before his associates the importance of geology to all serious students of geographical science, and he summed up much of what he had advanced, in lectures and papers on the subject, in *Earth Sculpture or the Origin of Land Forms* (1898; last edition, 1909). Dr. Geikie has now in the press another similar work dealing with the borderland of geology and geography, but treating more especially of mountains. Meanwhile his interest in the history of the Ice Age has not abated. A few months ago he delivered a course of lectures in the University (under the 'Munro Foundation') on the "Antiquity of Man in Europe", in which the subject was discussed mainly from the geological point of view.

As a teacher Professor Geikie has of course endeavoured to give as wide a view of the stony science as one man can be expected to do. In the early 'eighties' he had to do all the work of his department single-handed, lecturing, demonstrating minerals, rocks, and fossils in the laboratory, as well as conducting field excursions. By and by, however, the department was strengthened by the appointment of able lecturers and assistants, and is now probably as well equipped as any similar school in the kingdom.

Students of applied science are, as might be expected, more keenly interested in practical work than in palæontological research or historical geology. From the first, therefore, Dr. Geikie endeavoured to meet their special requirements by devoting the summer term to the study of structural and field geology, and in 1898 he issued a textbook on the subject, which has gone through three editions (the last appearing in 1912), so that the book has apparently met a 'felt want'. Some years ago he began to form a lending and consulting 'class library' for the use of his students, which has now grown to respectable dimensions, thanks largely to generous contributions of geological literature from his brother, Sir Archibald Geikie. It contains upwards of 5,000 volumes, and many thousands of 'separates' from the scientific journals of this and other countries, besides a large collection of geological maps. This library (with the consent of his brother) has been presented to the University.

While busy enough with his duties as a teacher, Professor Geikie yet found time to take part in the administration of the University, having acted since 1891 as Convener of the Science Degrees Committee, and subsequently, after a Faculty of Science had been instituted by the Royal Commission in 1894, his colleagues did him the honour to elect him their Dean, an official position which he still holds. Since James Geikie joined the University in 1882 great changes have taken place. Not only have several new Chairs in the Faculty of Science been founded, but numerous additional lectureships have been instituted, and the whole system of teaching has been in a measure revolutionized. More especially is this noticeable in practical work—

the provision for which is constantly being increased by the enlargement of old laboratories and the building of new ones.

As a relief from professional work Professor Geikie has indulged, as most folk do, in hobbies. One of these has been the study of foreign literature—not wholly geological, as the issue of a volume of translations of Heine's Songs and Lyrics may serve to show. But not much idle time outside his professional duties has been allowed him, for he has been twice elected a President of a section of the British Association, that of Geography in Edinburgh and of Geology at Newcastle; while the United States carried him off to America to deliver a course of lectures at the Lowell Institute in Boston.

Professor James Geikie received the Brisbane Medal of the Royal Society of Edinburgh and also the Murchison Medal of the Geological Society of London in 1889. In presenting the latter Dr. W. T. Blanford, then President of the Geological Society, said: "The Council has awarded the Murchison Medal to Professor James Geikie in acknowledgment of his important contributions to the geology of North Britain, and especially of his investigation of glacial phenomena. His *Great Ice Age* contained a full, careful, and admirably written summary of the observations made up to 1874, and the interest excited by the work was proved by a second edition being required in 1877. Professor Geikie has besides published numerous papers, not the least important of which were two that appeared in the Society's Quarterly Journal containing his observations 'On the Glacial Phenomena of the Long Island or Outer Hebrides'."

A third edition of his *Great Ice Age* (largely rewritten) was published in 1894, and although so long a period had elapsed since the second edition appeared it speaks highly for the author's merits and charm as a writer that the book had lost none of its interest with geologists, nor with the reading public in general.

One of the most important advances made in glacial geology is afforded by the various evidences which have been brought to light which tend to establish the conclusion that prehistoric man was living and resident in Europe probably before the Great Ice Age, and certainly during the several mild interglacial periods which occurred prior to the final removal of the intense cold and the great permanent snow-fields of the Northern Hemisphere. In a valuable and exhaustive notice of Dr. James Geikie's work at the time (see GEOL. MAG., 1895, pp. 29–38) Dr. Hinde observes: "Opinions may differ respecting some of the generalizations of the author, but all will agree on the value and importance of having the evidence on this subject stated in so clear and impartial a manner."

The warmest personal regard is entertained for Professor James Geikie, not only by his many friends and fellow-workers, but by the still larger number of those students who have come under the influence of his teaching and his writings during the past thirty years, and he will always be remembered as having added new impulse both to geography and geology, especially in the University of Edinburgh, where his name and services are not likely soon to be forgotten.

LIST OF SCIENTIFIC PUBLICATIONS BY PROFESSOR JAMES GEIKIE, F.R.S., ETC.

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1868. "On Denudation in Scotland since Glacial times": Trans. Geol. Soc. Glasgow, vol. iii, pp. 54–74; ibid., Vol. V, pp. 19–25.
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1871. "Carboniferous Formation of Scotland," remarks on Mr. Croll's letter: Trans. Geol. Soc. Glasgow, vol. iv, pp. 78–80; GEOL. MAG., Vol. VII, 1870, p. 298.
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II.—Notes on new or imperfectly known Chalk Polyzoa.

By R. M. Brydone, F.G.S.

(*Continued from the May Number, p. 199.*)

(PLATE VIII.)

AVICULARIA of what I have called the *Lesueuri*-type are not confined to *Membranipora*. There are at least two species provided with them which come nearer to *Semieschara*.

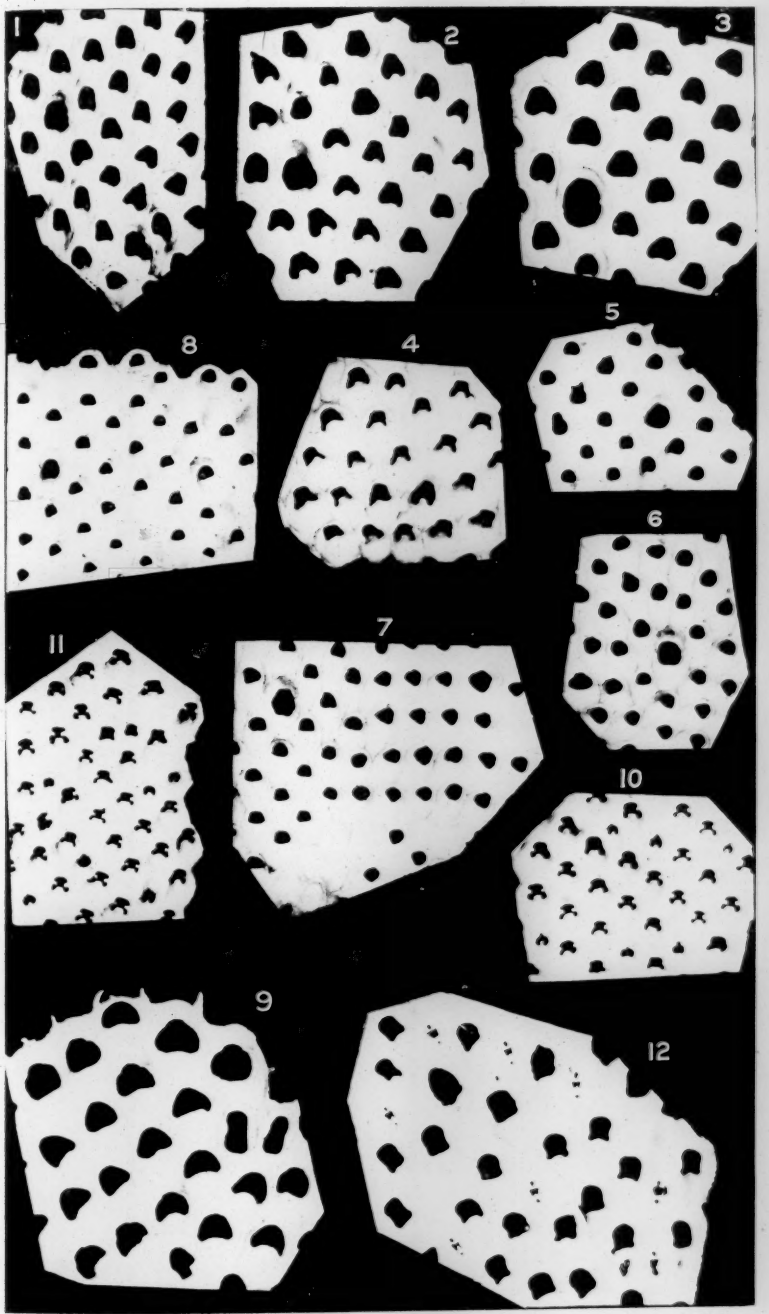
Semieschara labiatula, sp. nov. (Pl. VIII, Figs. 1–4.)

Zoarium always adherent.

Zoœcia subpyriform, with separate side walls which are broad and pass gradually down into the front wall; apertures large and subtriangular, with the apex flattened owing to the development of a slight internal front wall, fairly straight sides with a tendency to bulge inwards towards the top and a lower lip always more or less convex with an upturned tip which catches the light and is very useful for rapid recognition; these convexities are most marked in the later forms and may be so pronounced as to make the aperture definitely trifoliate (Fig. 4).

Oœcia abundant, narrow helmet-shaped swellings of the foot of the succeeding zoœcium.

Avicularia abundant and typical; aperture broadly elliptical, but with a distinct tendency to assimilate itself in general outline to the zoœcial aperture (especially in the lower lip, which may be strongly convex), the lower section nearly or quite equal in size to the upper; the infold of the side wall sudden, with a concave edge; avicularia of a modified form looking as if a small zoœcium had been set into the aperture of a normal avicularium occur very sparingly (Fig. 2).



R. M. Brydone, Photo. Beaurose, Collo.

Chalk Polyzoa.

The species occurs rarely and of small size in the upper subzone of the zone of *O. pilula*, and becomes fairly common in the restricted zone of *A. quadratus* but remains small; at Trimingham it is abundant and distinctly larger, occasionally attaining a very considerable size. I have no specimens from intermediate horizons.

The avicularia enable it to be distinguished at once from such species as *Cellepora Villiersi*, D'Orb.,[1] or the earlier figures of *Eschara Delarueana*, D'Orb.,[2] to which zoœcially it bears some resemblance.

SEMIESCHARA OCCLUSA, sp. nov. (Pl. VIII, Figs. 5–8.)

Zoarium always adherent.

Zoœcia long and pyriform, with separate side walls; apertures more or less semicircular, with strongly rounded corners and slightly flattened at the head by the development of a tiny internal front wall; imperforate lids which completely seal up the aperture are preserved here and there all over the zoarium and abundantly among the early zoœcia.

Oœcia abundant, narrow helmet-shaped swellings of the foot of the succeeding zoœcium.

Avicularia apparently very similar to those of *S. labiatula*, but with the infold of the side wall in such low relief that it is very difficult to make out its details (the definiteness of the illustrations has largely accrued in the process of reproduction); apertures normally enlarged copies of the zoœcial apertures, but with a distinct tendency to rectilinear outlines, which sometimes goes so far as to turn them into rude hexagons; modified avicularia similar to those of *S. labiatula*, but much less conspicuous, are fairly common.

The species is common at Trimingham, especially in the lowest beds exposed there, and probably therefore has a further range downwards, and as this range does not extend to the Weybourne horizon it may possibly be of assistance in identifying Chalk intermediate between the Trimingham and Weybourne horizons.

SEMIESCHARA MUNDESLEIENSIS, mihi.[3] (Pl. VIII, Fig. 9.)

The original figure of this species was inaccurate, and as it is near enough to *S. labiatula* for comparison I give a photograph of the type. It will be seen that the avicularia are constructed on the same general plan of infolded side walls as the *Lesueuri*-type, but cannot be included in the latter, as they are not conspicuously larger than the zoœcia. I have found rather primitive specimens of this species very occasionally in the *mucronata*-chalk of the Isle of Wight and Hants.

SEMIESCHARA CANUI, mihi.[3] (Pl. VIII, Figs. 10, 11.)

ESCHARA ROWEI, mihi.[3] (Pl. VIII, Fig. 12.)

I take this opportunity of supplementing the diagrammatic original figures of these species by photographs of specimens lending themselves to photography more kindly than the types.

In the case of *S. Canui*, Fig. 10 shows that this species possessed oœcia in the shape of large, flat, rather inconspicuous swellings,

[1] Pal. Franç., tom. v, p. 407, pl. 605, figs. 8, 9.
[2] Tom. cit., p. 105, pl. 602, figs. 6–8.
[3] GEOL. MAG., 1906, pp. 289–300.

a perfect one and one unroofed being visible. They are of rare occurrence. The avicularian aperture has a semicircular upper lip with unbroken curve when perfect, as shown by the original figure and Fig. 11, but the regularity of the notches shown in Fig. 10 suggests a median line of weakness, perhaps indicating that the species started with a notch there, the filling up of which was not yet fully consolidated.

In the case of *E. Rowei* it is clear that the outline of the avicularian aperture was misrepresented in the original figure, and that it has a straight lower lip and diverging sides and a convex upper lip, and that the lower lip bears a long slender denticle.

EXPLANATION OF PLATE VIII.

(All figures × 12 diams.)

FIG. 1. *Semieschara labiatula*. Zone (restricted) of *A. quadratus*, Upham, Hants.
FIGS. 2, 3. *S. labiatula*. Trimingham. Normal specimens.
FIG. 4. ,, ,, Trimingham. Small form with trifoliate apertures.
FIGS. 5–8. *S. occlusa*. Trimingham.
FIG. 9. *S. Mundesleiensis*. Trimingham. Type-specimen.
FIGS. 10, 11. *S. Canui*. Trimingham.
FIG. 12. *Eschara Rowei*. Trimingham.

III.—On the Rigidity of the Earth, and on Colonel Burrard's theory of the Himalayas.

By the Rev. O. Fisher, M.A., F.G.S.

IN the April number of this Magazine a review appeared of Colonel Burrard's memoir[1] on the origin of the Himalaya Mountains. The writer, Sir T. H. Holland, in it refers to a paper of mine originally published in the Phil. Mag.,[2] and subsequently in an amended form as Appendix No. 1, 1905, Indian Survey Papers, professional vol. xviii. I shall be glad to make a few remarks upon the subject. After duly crediting me with having partially anticipated the results now obtained by the Survey, by calculating the deflection of the plumb-line in North India which would follow from my theory of mountain compensation by a 'root' extending to a depth of about 29 miles, the reviewer continues—"The variations now observed are, however, more violent than those expected by Mr. Fisher, for the northerly deflections of the plumb-line decrease to zero at a distance of about 15 instead of over 60 miles from the visible foot of the hills." I would reply that I have not calculated the deflection at 15 miles, and it is not safe to guess *a priori* what it would be. The numerical calculation for a given distance is tedious, and I could not now undertake it.[3]

Though Sir T. H. Holland appears to admit that my theory (or rather Airy's) of mountain roots goes some way to account for the observed deflection, he nevertheless adds that it does not "march", like Colonel Burrard's, "with the growing belief in a solid earth."

[1] Survey of India, professional paper No. 12, Calcutta, 1912.
[2] Phil. Mag., January 7, 1904.
[3] In the Phil. Mag., p. 24, in the formula for the attraction of the plateau, there is a misprint. After the first bracket insert x.

This statement possibly refers to Professor Hecker's observations on the bodily tides of the earth. I understand the word 'solid' as opposed to 'fluid', not as equivalent to 'rigid'. Is it not possible that there may be a liquid substratum to the earth's crust, and the earth may nevertheless be rigid with respect to the external disturbing forces of the attraction of the moon and sun as evidenced by tides? By way of illustration, we are quite unconscious of the rotation of the earth on which we stand. But if we could observe the earth with a telescope from the moon, the effect of rotation would be very marked by the rapid passage of objects near our equator across the field of view. Is it not possible that the earth's rotation may impart to it a 'gyroscopic' *quasi* rigidity, which may enable it to withstand the deforming influence of external forces, although at the same time forces internal to the earth will be unaffected by it.

Professor Perry, in his little book on spinning-tops, illustrates how "rapid motion gives a peculiar *quasi* rigidity to flexible and even to fluid things. Here," says he, "is a disk of quite thin paper; and when I set it in rapid rotation you observe that it resists the force exerted by the blow of my fist as if it were a disk of steel. Hear how it resounds when I strike it with a stick. Where has its flexibility gone?"

In the highly interesting and instructive paper which Sir G. H. Darwin read at the Geodetic Conference of 1909, giving an account of Hecker's observations of the tidal deformation of the earth, he reproduced Hecker's curve, which represents the rigidity both in north and south, and east and west directions. The radius of this curve is proportional to the rigidity, and shows in a remarkable manner that the rigidity is much greater in the east and west direction than in the north and south. And in the discussion that followed Darwin said that he "considered as worthy of consideration Professor Hecker's explanation of the remarkable absence of symmetry in the path of the vertical" (that is, the difference of rigidity in different directions, Hecker's explanation depending upon the geographical situation of Potsdam), "but he suggested an alternative possibility. The curve was much compressed in the north and south direction, showing that the earth has much greater rigidity east and west than north and south. It is possible to explain this to some extent by the earth's rotation. Lord Kelvin introduced the idea of 'gyroscopic', that is of greater rigidity east and west due to rotation. Whether this is a sufficient explanation cannot be said, because no one has succeeded in solving completely the gravitation problem of a rotating elastic globe";[1] nor yet, I believe, of a partially liquid one. Although it may be that rotation imparts a greater rigidity in the equatorial direction, yet Professor Perry's experiment quoted above shows that there is great rigidity imparted in the axial direction also. If rotation is competent to impart the needful excess of rigidity, it may be pertinent to ask, why not the whole of it?

I do not remember ever to have seen changes of level accounted for on the hypothesis of a solid earth. There also appears to be some

[1] *Nature*, vol. lxxxi, p. 427, October 7, 1909.

reason for believing that alterations in the force of gravity are even now going on at Dehra Dun in India, which would indicate internal movements of mass incompatible with solidity.[1]

Colonel Burrard's theory, of a rift in the sub-crust along the area of low density skirting the mountain range, will no doubt receive the consideration which the high position of its author demands for it; but it is obvious that there are difficulties. He appears to believe that the sub-crust beneath the mountains contracted upon itself, and in being shortened laterally became thickened vertically, and rose up into a mountain range, leaving a rift where it parted from the adjacent sub-crust. If it was in a state of tension, it is conceivable that a rift might have been formed, and that it might have contracted upon itself until the tension was relieved. During this part of the process it would have decreased in volume and become more dense. Then it seems to be supposed that the process of lateral contraction continued, and, contrary to what might be expected, it became less dense. A decrease of mass below corresponded to the protrusion of the mountains above. The material remaining below thus became less dense than the mountains which it pushed up, and *that* in spite of the pressure. Thus partial isostacy would result. These movements being supposed to have gone on in a sub-crust, any rift formed by them would appear to have been more likely to open from below, and to have been filled with heavy material rather than with sediment from the surface. Rifts have been abundantly formed among the older rocks, but they are never empty, but filled with some intrusive material or mineral veins, usually of a denser character than the country rock. An empty rift would be an anomaly.

In any theory of a mountain range allowance must be made for the enormous amount of material which has been denuded from it; in the case of the Himalayas, the Sewalik range, the alluvium of all the Indo-Gangetic plain, besides what has been carried out to sea by rivers. Elevation in compensation of this waste is continually going on, and it is probable that it is this which is the cause of the frequent earthquakes that occur in the district.

IV.—The Minerals of the Barrington Bone-bed.

By R. H. Rastall, M.A., F.G.S.

ONE of the most important and most interesting features of the geology of the Cambridge district is the deposit at Barrington, so widely known for its richness in mammalian remains. This bone-bed has been described many times, and the literature is large. Most of the descriptions, however, confine themselves chiefly to the organic contents, mentioning briefly the character of the larger stones and pebbles, and saying little or nothing about the nature of the finer matrix in which these are embedded.

The author has been for some time past engaged in the study of the mineralogical composition of the sands and gravels of Pleistocene

[1] See Colonel Burrard's paper, Phil. Trans., ser. A, vol. cev, 1905. Also *Nature*, vol. xci, p. 143, 1905.

and Recent age in this district, with a view to ascertaining whether the character and possible derivation of the smaller mineral grains might throw any light on the correlation of these puzzling deposits. Some of the results have been already published,[1] while other groups are still under investigation. Since the Barrington Bed is so widely known, and so peculiar in character, it seemed advisable to accord it separate treatment.

The earliest detailed description of the lithological character of the bone-bed appears to be that given by the Rev. O. Fisher in 1879[2]; it is as follows:—

"The materials of which the bone-bearing deposit consists are peculiar. The matrix is a grey sand with a slight admixture of clay. The pebbles consist of flint in subangular pieces of no great size, sometimes ochreous, sometimes grey, sometimes black. These are not rounded, but have their surfaces worn, polished, and the angles rubbed off. There are rolled lumps of Chalk-marl and a considerable admixture of 'coprolites', as might be expected, seeing that the coprolite-bed is abraded by the deposit itself. The remaining pebbles are well-rounded pieces of crystalline rocks, consisting of quartz, quartzite, syenite, jasper, and trap. These old rocks contribute a large part of the pebbles, so that the material cannot be called a flint-gravel, in that it appears to consist of the least destructible parts of the Boulder-clay, mixed with materials from the Chalk-marl and Greensand.

"There appear to be very few remnants of the Oolitic rocks among the pebbles, except a few fragments of *Gryphæa*. The pebbles are, for the most part, not at all decomposed, as those are which one now picks up in the neighbouring ploughed fields, and the glacial scratches are well preserved."

The foregoing description was penned at a time when the facilities for a thorough examination were greater than at present exist. The section is described as extending for 70 yards from north to south, and workings were then in active operation. It only remains to add, what is not perhaps there made sufficiently clear, that many of the so-called 'pebbles' are large stones, weighing as much as 14 or 16 lb., and that large, well-rounded boulders of hard white Chalk are common. It is, however, mainly with the finer material of the beds that we are here concerned, and the characters and origin of the larger constituents, though a topic of great interest, cannot be further discussed.[3]

Since the deposit shows a good deal of variation from top to bottom, several samples were collected from different parts, and of these three are here more particularly described.

1. This specimen was obtained about two feet from the top of the bed. It may be described as a white chalky gravel and sand,

[1] "The Mineral Composition of some Cambridgeshire Sands and Gravels": Proc. Camb. Phil. Soc., vol. xvii, pp. 132–43, 1913.

[2] "On a Mammaliferous Deposit at Barrington, near Cambridge": Quart. Journ. Geol. Soc., vol. xxxv, pp. 670–7, 1879.

[3] For the most recent description see Hughes, "Excursion to Cambridge and Barrington": Proc. Geol. Assoc., vol. xxii, pp. 268–78, 1911.

containing a good many small flints and pebbles of hard Chalk. After passing through a sieve to remove the larger fragments, the material was washed with water. After prolonged washing the white chalky mud was removed and the residue was found to be a clean white sand, consisting of approximately equal parts of colourless quartz and white calcareous matter, chiefly Chalk in small rounded grains. There were also abundant white prismatic structures, apparently including both prisms from the shells of *Inoceramus* and spines of Echinoids. Red, brown and black grains constitute only a small proportion of the whole, while glauconite is also to be seen occasionally.

With dilute acid the effervescence was naturally very copious, and the insoluble residue was a notably white sand. The heavy constituents of the sand were then roughly concentrated by panning, and finally separated in bromoform in the usual way.

The principal minerals noted in the ultimate residue were as follows: garnet, abundant, in angular, subangular and rounded grains, often very strange shapes, either colourless, pink, or pale brown; tourmaline, common, in round grains or less commonly idiomorphic crystals, generally brown; kyanite, rather abundant, in angular fragments or rounded grains; staurolite, in rounded grains, a rather unusual circumstance; muscovite, in small quantity, chiefly in minute flakes. Other less common transparent minerals were green and blue hornblende, deep-red rutile and yellowish-green epidote. Among the opaque constituents the most abundant were pale-brown rounded grains of indeterminable nature, together with a smaller quantity of magnetite. The significance of this assemblage of minerals and their probable source will be discussed in the concluding section.

2. This was a small sample collected from near the middle of the bed. In general character it was much like the last, and the residue of white sand was almost identical in appearance. The chief minerals found in the rather scanty heavy residue from bromoform were as follows: garnet occurs in grains rather larger than the rest, colourless, pink or brown, and of a great variety of shapes, often very angular, though some are distinctly rounded. Hornblende is common, chiefly of the ordinary green variety, though some grains have a blue tinge. Staurolite and kyanite are rather abundant in fairly large grains, although tourmaline is not very common. Among other transparent constituents rutile and epidote are the most notable, zircon being quite rare. Muscovite also occurs in small flat flakes. When examined by reflected light magnetite is seen to be very common, and there are also opaque white and brown grains. The general form of the mineral grains shows much variation, some being conspicuously rounded while others are just as notably angular. It is probable that the very round grains have been obtained in that state from some older formation.

3. This specimen is of special interest, since it represents the lowest part of the deposit, the actual bed in which the bones are found. It is a white marly substance, soft and rather plastic when fresh and moist, but when dried setting into a hard mass. This, however, falls

to pieces readily when placed in water. The preparation of the specimen was difficult, since very prolonged washing is needed to get rid of the fine white chalky mud. When this had been removed there was left a mass of fine gravel and sand with flints and Chalk pebbles and many shells. The latter were mostly in a very fragmentary condition, though some were unbroken. A large proportion of the residue consisted of very fine sand, and in this minute grains of brilliant green glauconite were visible. After concentration by panning, the heavy minerals were found to be present only in small amount, and the grains were also less in size than in the other specimens. The only abundant mineral is white mica, in thin flakes of varying size. Besides this there were a few crystals and broken fragments of garnet, together with rounded grains of hornblende and a very few zircons. One grain of rutile was seen and one flake of kyanite; magnetite is not very abundant. The general assemblage of minerals in this sample is much the same as the others, the chief difference being the much greater abundance of muscovite. This latter fact is probably to be correlated with the preponderance of finely divided material.

In connexion with the foregoing descriptions several points present themselves for discussion. In the first place the chalky material which is so abundant clearly belongs to two different types: the fine chalky mud is undoubtedly derived from the underlying Chalk Marl which forms the bed-rock of the deposit. But the pebbles and grains of Chalk, of rounded form, which are such a characteristic feature, are for the most part much harder than the Chalk of the Cambridge district, and must have been transported by ice from more northern localities. The very brilliant green grains of glauconite must have been derived from the Cambridge Greensand, which underlies the bone-bearing deposit over part of its extent. Grains of glauconite derived from the Neocomian show a duller shade of green of a quite different tint, easy to recognize, though difficult to define in words.

The general assemblage of heavy minerals here identified is, on the whole, similar to that found in the other Pleistocene and Recent gravels of the Cambridge district. There is, however, one notable exception, namely, the occurrence at Barrington of abundant white mica, a mineral which is notably absent from other localities, although it is fairly common in some fine sands and marls near Newmarket, and is abundant in a sand on the summit of the Gogmagog Hills. The sporadic distribution of mica in these deposits is a curious circumstance for which no plausible explanation has yet been found.[1] Of the other minerals the most interesting are tourmaline, kyanite and staurolite, which, as is shown in the paper previously cited, have probably been derived from the Neocomian rocks. The garnet, hornblende, zircon, rutile and others, are believed to have been for the most part obtained from the far-travelled constituents of the Glacial Drift, which has undoubtedly provided a great proportion also of the larger elements composing the superficial deposits of this district.

[1] See Proc. Camb. Phil. Soc., vol. xvii, p. 142, 1913.

V.—The Limbs of *Lystrosaurus*.

By D. M. S. Watson, M.Sc., Lecturer in Vertebrate Palæontology, University College, London.

Lystrosaurus, Cope = *Ptychognathus*, Owen (*non* Stimpson), has long been known from isolated but often perfectly preserved skulls. Quite recently the reception of a magnificent skeleton by the Albany Museum, Grahamstown, enabled me to give a restoration of the animal. In this drawing the hand and foot were drawn from incomplete non-associated remains. Whilst travelling in South Africa, with the aid of a grant from the Percy Sladen Trustees, I collected on the farm Klip-kuil a fragmentary skeleton of *Lystrosaurus*, much of which was so rotten that it could not be preserved, but which included a complete left fore-limb. This was developed by myself and was found to lie in its natural position with the digits very

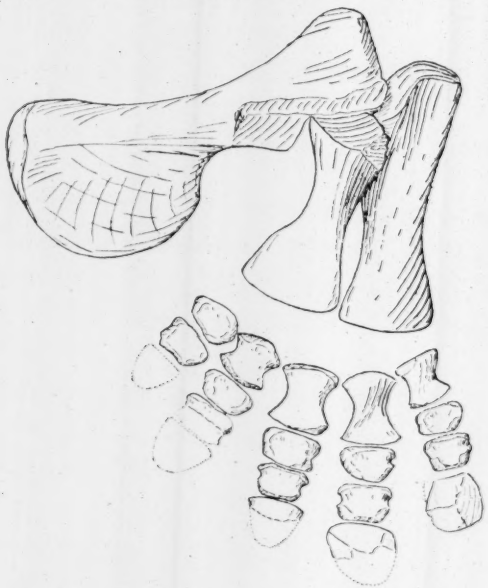


Fig. 1. Left forearm of *Lystrosaurus* sp., Klip-kuil, District Albert, Cape Colony. Viewed from the front. × ½. The lower end of the humerus is broken so as to show the articular face of the upper end of the radius.

strongly flexed, except that the metacarpals were slightly separated laterally. It is represented in Text-fig. 1, with the humerus, radius, and ulna in the position in which they were found, and with the fingers extended. The humerus is not very well preserved, but agrees exactly with the excellent example figured by Owen, *Catalogue of South African Fossil Reptiles*. It is of the usual Anomodont type, with a very powerful deltoid crest extending halfway down the shaft, and a much expanded lower end with a large entepicondyle. There is a large entepicondylar foramen, but no

ectepicondylar perforation. The bones of the forearm agree with those of the Albany Museum skeleton. The radius is a short bone, with a narrow, nearly circular, shaft, expanded at the top to a head, which is provided with an articular face divided by a ridge into two parts, the anterior articulating with a face on the front of the humerus, the other jointing with that on the head of the ulna to articulate with the end of that bone. The lower end is much expanded laterally. The ulna has a stout head of triangular section, its antero-internal face articulates with the head of the radius, and its articular face for the humerus is continuous with one of those of the other bone. There is no produced olecranon process, but the bone has obviously had a cartilaginous expansion in this region. The shaft is thin and the lower end laterally widened.

As in all Anomodonts, the forearm was carried at right angles to the humerus and had probably only a very limited range of movement. Looked at from the front, the head of the radius lies before a good deal of the head of the ulna, so that there is some crossing. Study of well-preserved shoulder-girdles shows that the humerus was carried generally at right angles to the body, as in most primitive reptiles and the living Monotremes. In this individual there is no ossification in the carpus, and its length is uncertain. All five metacarpals are preserved; the first is a rounded nodule of bone, from the second to

FIG. 2. The upper ends of the radius and ulna of the specimen represented in Fig. 1. × ½.

the fifth there is a perceptible shaft, and the bones increase in length to the fourth, which, as is usual in reptiles, is the longest.

The first phalange of each digit is a curious nodule of bone, which in longitudinal section is triangular, the dorsal surface being flat and the two articular surfaces nearly meeting below. The second phalange of the first digit is not preserved; those of the other fingers are flat, and have a trace of a shaft in a notch on either edge. Their articular faces are parallel. The third phalanges of the third, fourth, and fifth digits are flat, very thin, and spreading. Taken as a whole the hand is an aquatic modification of the ordinary Anomodont type; the chief modifications are the excessive breadth, the flattening of all the bones, and the great expansion of the terminal phalanges. The most curious feature is the triangular section of the first phalange, which allows of very great flexion of the digits; the same feature occurs in *Kannemeyeria* and in Monotremes, to the foot of which that of Anomodonts offers many striking resemblances, as Owen, Seeley, and Broom have already recognized.

Amongst the series of South African fossils presented to the British Museum by Mr. David Draper, the well-known Johannesburg geologist, is an extremely well-preserved fragment of *Lystrosaurus*

from Harrismith, O.F.S. This shows the lower end of the tibia and fibula, the tarsus, and some metatarsals and phalanges. The tibia is not at all compressed, the lower articular face being almost circular. The fibula is a much more slender bone than the tibia; its narrow shaft, however, flares out somewhat to the distal articular face, which is flat. There are two tarsals, nearly spherical masses of very spongy bone, with flattened dorsal and ventral surfaces; these two bones enclose the usual foramen, and are so situated in relation to the fibula as to show that that bone articulated with both of them. In this specimen and in another quite similar one, also in the British Museum, the large articular face of the tibia does not face any bone, and it seems quite certain that a large part of it only articulated with a cartilage during the life of the animal. The arrangement is, in fact, extraordinarily like that of *Limnoscelis* as figured by Williston (*Amer. Journ. Sci.*, vol. xxxi, p. 396). The most reasonable explanation seems to be that the two bones are the fibulare and intermedium, the tibiale being unossified. This interpretation is supported by the very curious fact that in Plesiosaurians, where the

Fig. 3. The lower ends of the tibia and fibula, the complete tarsus, three metacarpals, and some phalanges of the left side of *Lystrosaurus*. From Harrismith, O.F.S. × ½.

intermedium is always separated from the tibiale, that bone does not ossify in *P. Hawkinsi*, and is only represented by a very small nodule of bone in *P. rugosus*.

The great amount of cartilage remaining unossified about both *Limnoscelis* and *Lystrosaurus* is rather remarkable, as the Seals and Sirenia, which seem to offer the best comparison from the point of view of probable habits, are well ossified.

The three metacarpals preserved are slender, long-shafted bones, little compressed, and their proximal ends are very close to the two ossified tarsals, so that the cartilaginous distal tarsals were probably much reduced. The few phalanges preserved are similar to those of the hand.

One of the incomplete feet of *Lystrosaurus* in Grahamstown shows four phalanges on two neighbouring digits, so that in the foot this type exceeded the normal mammalian number of 2, 3, 3, 3, 3 of phalanges which occur, as shown by the specimen just described, in the hand.

VI.—On the Occurrence of the Lynx in North Wales and Derbyshire.

By J. Wilfrid Jackson, F.G.S., Manchester Museum.

ON looking over a miscellaneous collection of animal bones from a cave in North Wales, sent to me for identification by Mr. John H. Morris, of West Bromwich, I was pleased to discover the remains of the lynx, and as our knowledge of the occurrences of this animal in the British Isles is so scanty, it seems to me to be of some interest to record the present discovery.

Hitherto remains of this creature have only been recorded from a few places in this country. It was first discovered about 1866 in a fissure, termed the Yew-tree Cave, in Pleasley Vale, on the borders of Nottinghamshire and Derbyshire, the remains consisting of a right ramus of a lower jaw and the hinder part of a skull.[1] Fourteen years later two bones, a humerus and a metatarsal, were met with in a fissure in Teesdale, Durham, and were described by Mr. William Davies.[2] In 1897 its remains were met with in fair quantity, by Mr. W. Storrs Fox, in a cave in Cales Dale, Derbyshire,[3] while the most recent record appears to be that of the Rev. E. H. Mullins, who gives it in his list of animals found in Langwith Cave, near Mansfield.[4]

The North Wales cave, the site of the present discovery, is situated some two and a quarter miles to the south-east of Prestatyn and is known as Gop, or Newmarket, Cave. It is the same cave from which Professor Dawkins obtained the remains of the hyæna, bison, reindeer, woolly rhinoceros, etc., as well as domestic animals, pottery, and human bones, indicating that the cave had been used at a later period both for habitation and burial purposes.[5]

Displacement of stalactitic matter behind the area explored by Professor Dawkins revealed the presence of a continuation of the cave in the form of low tunnel from which other tunnels strike off to the right and left. The one on the left leads back to the cliff where an entrance has at some remote period been artificially closed by a barrier of limestone.

The discovery of these further passages led to explorations being made by Mr. John H. Morris, Lieut.-Colonel T. A. Glenn, and others, in 1912, with the result that several other remains, both animal and human, were met with in digging into the cave-floor in different places.

Amongst the animal bones sent to me for examination I have been able to identify those of the bison, bear, badger, fox, wolf, roe, stag, horse, hare, ox, sheep, pig, domestic fowl, coot, etc., as well as the lynx, as mentioned above.

The bison and bear are each represented by one bone only, in the former case by a left magnum, and in the latter by an imperfect left humerus wanting both extremities. As to the species of the

[1] W. Boyd Dawkins, *Brit. Pleist. Mam.* (Pal. Soc.), i, p. 172, 1869.
[2] Wm. Davies, Geol. Mag., 1880, p. 346.
[3] W. Storrs Fox, Proc. Zool. Soc., i, p. 65, 1906.
[4] Journ. Derbyshire Archæol. and Nat. Hist. Soc., vol. xxxv, p. 150, 1913.
[5] Dawkins, Archæol. Journ., lviii, pp. 322–41, 1901.

latter it is difficult to decide; the bone agrees with a corresponding bone of the brown bear (*Ursus arctos*) in the Manchester Museum, and in all probability belongs to that species.

With the exception of the lynx and wolf, all the other animals are well represented by several parts of their skeletons. Most of these, however, appear to have been met with in association with the human remains found in the cave, and without doubt belong to a later period.

The lynx is represented by the right ramus of the lower jaw containing only the carnassial tooth, the others being represented by their sockets. The ramus is almost complete, wanting only the angle and part of the articular condyle; the alveolar border is more curved than the inferior, and the jaw is thickened anteriorly. There is a small convexity of the inferior border owing to the ramal process being slightly developed.

Compared with the examples from Pleasley and Cales Dale, the Gop jaw is somewhat smaller, but appears to belong to the same species, viz. the Northern Lynx, *Felis lynx* (*borealis*).

The following table of measurements (in inches and tenths) shows the correspondence of the Gop jaw with those of Cales Dale, Pleasley, and a Northern Lynx in the British Museum (B.M. 1230A), these last three being taken from Mr. W. Storrs Fox's paper (op. cit., p. 68), and Professor Dawkins' *British Pleistocene Mammalia*.

Measurements of Right Ramus of Lower Jaw.

	F. lynx, Gop.	*F. lynx*, Cales Dale.	*F. lynx*, Pleasley.	*F. lynx* (*borealis*), B.M. 1230A
Maximum length	3·65(?)	—	4·2	4·0
Maximum height	1·66		1·68	1·8
Circumference behind m. 1	2·2	2·37	2·2	2·0
,, before p.m. 3	2·25	2·14[1]	2·4	2·0
Diastema	·2	—	·3	·3
Length of inferior border	2·7+	—	3·3+	3·5
Length of molar series	1·5	—	1·54	1·55
Antero-posterior extent of m. 1	·62	·68	·65	·65
Antero-transverse ,,	·25	·25	·26	·26
Postero-transverse ,,	·23	·26	·24	·26
Height of crown of m. 1	·33	·46	·35	·39
Symphysial length	1·1	—	1·25	1·1
,, breadth	·5	—	·5	·55

Unfortunately the geological age of the various remains in this cave cannot be determined with absolute accuracy, as, owing to the excavations of badgers, foxes, etc., it was impossible to be sure of the relative positions of some of the bones. The discovery, therefore, of the lynx throws no fresh light upon the question of the period at which this animal inhabited this country. That it lived side by side with the other fierce carnivores seems the most reasonable suggestion, for, as pointed out by Professor Dawkins (*Brit. Pleist. Mam.*), the

[1] Taken behind socket of canine, as p.m. 3 is entirely lacking.

carnivore in question must have crossed over into Britain when this country formed part of the mainland of Europe; for it is impossible to suppose that it could have invaded our Island from France or Germany during prehistoric times.

But what we should like to know more about is the period of its extinction in Britain. Like the wild cat it may have lingered in the wilder districts much later, say, than the lion, almost down to the historic period, for it appears to have only recently become extinct in France, a specimen being killed in the Haute Loire in the year 1822, while a second was killed in Württemburg in 1846.

In conclusion, I wish to thank Dr. C. W. Andrews for kindly confirming the identification of the lynx and several other forms. I am also indebted to Mr. J. H. Morris for allowing me to describe this specimen.

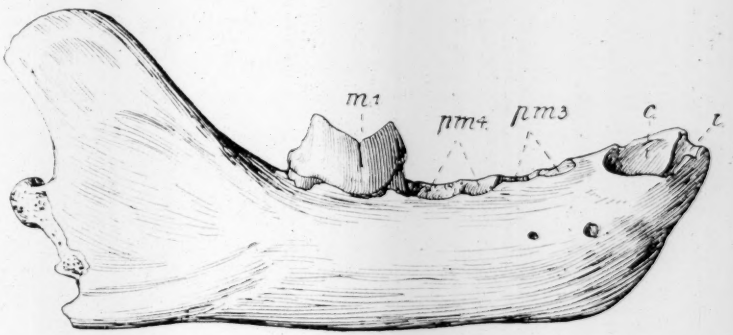


FIG. 1. Right ramus of the lower jaw of Lynx. Gop Cave, near Prestatyn, North Wales. Nat. size. *m. 1* = true molar; *p.m. 4* = socket for fourth premolar; *p.m. 3* = socket for third premolar; *c.* = socket for canine; *i.* = socket for third incisor.

Since writing the above note I have discovered a fragmentary right superior maxilla of a lynx in the Manchester Museum collections, the specimen being labelled as coming from Cales Dale, Derbyshire. It appears to have been in the Museum for some years and may possibly have been obtained during one of the explorations of Cales Dale Cave previous to that of Mr. Storrs Fox in 1897.

The specimen is of some interest on account of the entire absence of the anterior premolar tubercular tooth, with no trace of any alveolus. This feature appears to be one of the characters constituting MM. Croizet et Jobert's species, *Felis brevirostris*, remains of which were found in one of the Cresswell Crag caves (Robin Hood) and described by Dr. R. Laing in the Report of the British Association for 1889 (pp. 582–4).

The Cales Dale specimen being so fragmentary does not lend itself to detailed measurements, but one or two can be given. The total length of the canine is 1·75 inches, while the height of the crown is ·75 in.; between the canine and p.m. 3 there is a diastema of ·35 in.,

owing to the missing anterior premolar; p.m. 3 measures ·45 in. in length and ·25 in. in breadth, while the crown is ·35 in. in height.

The crown of the canine is supported by a strong sub-cylindrical fang; the inner surface of the crown is somewhat flattened and bounded anteriorly and posteriorly by two sharp ridges passing from the apex to the base. The external surface of the crown is strongly convex and traversed by two short but fairly deep furrows near the apex—the inner surface is without furrows.

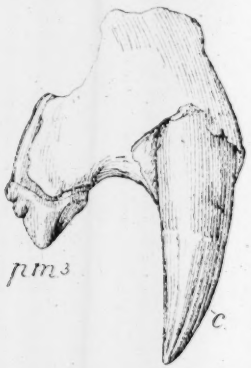


FIG. 2. Fragment of right upper maxilla of Lynx. Cales Dale Cave, Derbyshire. Nat. size. *p.m. 3* = third premolar; *c.* = canine. Note entire absence of second premolar!

The crown of p.m. 3 consists of a stout primary cone inclined inwards, as in *F. spelæa*, but is without the usual secondary cusp on the antero-internal aspect; the secondary and accessory cusps are present behind, and divided from each other by clefts. A sharp ridge traverses the tops of these cusps to the apex of the primary cone, thence it continues as a blunt ridge down the antero-internal slope. The cutting lobes are, therefore, all on the posterior slope of the tooth.

The absence of p.m. 2 is remarkable and suggests reference to the form known as *F. brevirostris*, but as this tooth is frequently entirely wanting in small specimens of the lion, tiger, and *F. spelæa*,[1] it may not be of any great significance.

VII.—Submerged River-valleys.

By R. M. Deeley, F.G.S., Memb. Inst. C.E.

BATHYMETRIC surveys have revealed much that is very interesting concerning the ocean floors, not only as regards the deeper portions, but also as concerns the continental shelves. Hull has constructed charts of the North Atlantic and shown that many of the shallower areas are of such a form as to suggest that they were originally portions of existing river-basins, and that the submerged valleys may be traced along the sea bottoms to depths of more than a thousand feet round the present continents. Similar

[1] *Brit. Pleist. Mam.* (Pal. Soc.), i, p. 69, 1868.

submerged troughs have also been noted along the margin of the Asiatic continent. Two such well-marked channels occur in the ocean at the mouths of the Indus and Ganges. Indeed, the phenomenon would seem to be one common to all the continental shelves.

Attempts have been made by some to explain the existence of these apparently submerged valleys by assuming that the set of the ocean currents tends to erode the ocean floor and produce depressions which simulate river-valleys in the adjoining seas. This explanation, however, does not seem to have met with much favour; for it assumes the existence of ocean currents which have not been observed, and also assumes that such currents, if they exist, could erode the ocean floor at very great depths. By others it has been suggested that these continental sea-shelf prolongations of existing valleys are recent land areas which have been submerged. If such depressions were local such an assumption might be made with some certainty, but as they are a common feature all over the earth the questions naturally arise—Where, if they are due to a rise in the sea-level, has the water come from, and how, if they are due to a sinking of the land, comes it about that this has affected all the continental shelves at the same time?

The difficulty, however, disappears if we regard these continental shelf depressions as of all ages. The present river-valleys and river-basins are certainly, in the main, of very great age. Indeed, we should treat the seaward prolongations of valleys as proving submergence, just as we treat beds containing marine fossils which are now found at great heights above the sea as proving emergence resulting from the rise of the land. It is not now suggested that elevated marine beds indicate that the sea once stood at that level. The volume of water in the oceans must be regarded as a fixed quantity, the apparent changes in the level of the sea being the result *mainly* of oscillations of the earth's crust. According to this view these submerged valleys may not be of any particular age. Indeed, some of them may be of Palæozoic age. The actual ages can only be ascertained by a study of the deposits on their floors and margins, just as the ages of the deposits forming the land surfaces are ascertained by the nature of the fossil remains they contain.

VIII.—Note on South African Cretaceous Dinosaurs.

By E. H. L. S.

THE result of the Tendaguru expedition to German East Africa has been the discovery by Drs. W. Janensch and E. Hennig of some forty Dinosaurs, ranging in size from forms larger than *Diplodocus* to ones as small as a pointer dog; these finds may be extended since Dr. H. Reck has proceeded to the locality with the intention of digging for a further year. In a paper by Dr. Hennig on the possible extension of the Dinosaur deposits[1] this author calls attention to the discovery by the late Dr. W. G. Atherstone of Dinosaur remains in the Wood Bed (Lower Cretaceous) of Bushman's River. In his

[1] Sitz. Ges. naturf. Freunde, Berlin, 1912, pp. 493–7.

description, published in the *Eastern Province Magazine*, Grahamstown, 1857, Dr. Atherstone states that a large part of the skeleton as well as the skull was discovered, but the only parts so far described are two skulls named by Owen *Anthodon serrarius*. Very little is known of this form, and Zittel places it in the Pareiasauridæ as a Karroo reptile. Dr. R. Broom described another Dinosaur from the same beds at Despatch, near Port Elizabeth, under the name *Algoasaurus Bauri*.[1] Messrs. Rogers and Schwarz mention Dinosaur bones as occurring in the sandy beds along the Bezuidenhouts River in Uitenhage,[2] and some detached bones and teeth from these beds are exhibited in the Albany Museum, Grahamstown. All these remains are of comparatively small animals for Dinosaurs. In the recent Whitsuntide holidays Professor E. H. L. Schwarz took his students to the Bushman's River, and in Dr. Atherstone's "Iguanodon Hoek" they discovered the femur of one of the gigantic forms. The bone was broken, and only the two ends were recovered; the shaft, having only slender walls, had splintered up, and for the most part had disappeared, but when whole the bone was some five feet in length. A further find of a smaller form was made a little lower down, but the bones were very much decomposed and no attempt was made to dig them out. A properly equipped expedition will be sent to the place by the Albany Museum, and there is every prospect of obtaining one or more of these gigantic skeletons. Close to the spot is the famous Alum Cave, whence the mineral Bushmanite, a variety of Apjohnite, is obtained.

REVIEWS.

I.—Geological Survey of Scotland Memoir.

The Geology of Upper Strathspey, Gaick, and the Forest of Atholl. By George Barrow, F.G.S., Lionel W. Hinxman, B.A., F.R.S.E., and E. H. Cunningham Craig, B.A., with contributions by H. Kynaston, B.A. 8vo; pp. vi, 116, with 2 text-illustrations and 4 plates. Edinburgh: printed for His Majesty's Stationery Office, 1913. Price 2*s*.

THE country described in this memoir is included in the Scottish colour-printed one-inch map, Sheet 64 (price 2*s*. 6*d*.). It is a mountainous area drained by the rivers Spey, Dee, Tilt, and Garry, and it extends over portions of Inverness, Perth, Aberdeen, and a small tract of Banff in the north-east.

The Highland schists known as the Moine Series occupy the larger portion of the ground, from the Spey Valley, with the favourite resort of Kingussie, over the western and east-central region, including Glenfeshie Forest, Loch an t-Seilich, Gaick Forest, and the northern part of the Forest of Atholl. This is a somewhat monotonous tract of tableland, rising 2,500 to 2,750 feet, intersected by deep trench-like valleys and with mountains that seldom reach 3,000 feet.

[1] Geol. Mag., Dec. V, Vol. I, pp. 445–7, Figs. 1–3, 1904.
[2] Ann. Rep. Geol. Comm. for 1900, Cape Town, 1901, p. 13.

To the south-east is the complex area bordering the Tilt Valley, where the Perthshire Series of Highland schists is divided by Mr. Barrow into (1) Central Highland quartzite, (2) Honestones or Parallel-banded group, (3) Little limestone (locally the Tremolite limestone), (4) Dark schist, (5) Main limestone, and (6) Calc-flintas. The order of succession, ascending or descending, is not known. The quartzite forms mountains, two of which rise to over 3,000 feet, and Mr. Barrow points out that they are "built up by the repeated folding on itself of one bed of sandstone, which cannot have been originally more than 30 feet thick, if so much. In the Benin à Ghlo Mountains the limbs of the folds are absolutely isoclinal, and attain an amplitude of at least 2,300 feet, with a persistent dip of 60 degrees to the south-east. This structure is exactly that produced by the shutting up of the bellows of a concertina, and may be conveniently called 'concertina structure'".

Associated with the Highland schists are certain intrusions of basic igneous rock, epidiorite and hornblende-schist, and intrusions of the older granites.

A large tract of newer granite forms the Cairngorm Mountains, with Ben Macdui 4,296 feet in elevation, and portions of Mar Forest in the north-east, being a part of "the largest area of continuous high mountain ground in Britain"; while to the south, and west of the Glen Tilt area with which it is associated, is another tract of the granite, which rises to 3,304 feet in Beinn Dearg and 2,992 feet in Beinn Bhreac. As remarked by Mr. Barrow, "a great historical interest attaches to this intrusion, for it was to the veins proceeding from it, so admirably seen in the Tilt at the old stone bridge above the Forest Lodge, that Hutton so confidently appealed in support of the view of the intrusive nature of granite, which he so ably expounded in his *Theory of the Earth*."

In the eastern part of the Cairngorm Mountains the granite, as described by Mr. Cunningham Craig, contains vertical or highly inclined veins of fine-grained material, which is "the chief source of the Cairngorm stones, which were at one time so much sought after". Various other igneous rocks, including diorites, lamprophyres, felsites, and quartz-porphyries, are described, and their influence on the scenery is pointed out.

In glancing at the map while perusing the memoir, it becomes evident how strenuous a task must have been the mapping of the rocks, the physical exertion alone being excessively arduous, and the localities where quarters could be obtained being few and lonesome. No doubt the attractions of fishing may have served to relieve the monotony, and rest the individual when stress of weather prohibited field-work.

Glacial deposits and peat extend over large areas, together with fluvio-glacial gravels (in the Spey Valley) and alluvium. It is remarked by Mr. Hinxman that "the effect of glacial action in modifying surface features is principally shown by the softened outlines produced by distribution of glacial detritus over the irregularities of the pre-glacial surface". Interesting observations are recorded on the scenery, the river-systems, and the changes they

have undergone. The valley of Glen Tilt, of which an illustration is given in the frontispiece, is a pre-Glacial gorge 1,000 feet deep in places, and of extreme straightness owing to erosion along the shatter-belt of a fault. During the period of maximum glaciation, ice-sheets, one from the far west and one that took a westerly or south-westerly direction from the Cairngorm range, became confluent for a time. Valley glaciers were formed later on. The effects of erosion during the Glacial epoch are best seen in the higher glens and corries, and in over-deepened valleys with bordering hanging valleys and waterfalls. A good view is given of a high-level corrie-tarn, Loch Coire an Lochain, which is held up at an elevation of 3,250 feet by the terminal moraine of the corrie-glacier.

There is no chapter on economic deposits, but there appear to be none of much importance. Mention is made in the course of the memoir of the honestones and the cairngorms that were formerly worked, also of the peat. It is noted by Mr. Barrow that "a feature of the Bynack peat is the great number of roots of fir-trees met with, which are seen protruding from the wasting edges of the peat along the stream banks. In this ground there are three tiers of these fir-roots rising one above the other; when dried they form a valuable fuel, as they burn like a candle, and in old days were actually used for that purpose". Splinters have similarly been used in Sutherlandshire.

A bibliography forms the concluding part of the memoir, and it may be added that the map is clearly colour-printed and in all respects excellent.

II.—Geology of Egypt.

The Geography and Geology of South-Eastern Egypt. By J. Ball, Ph.D., D.Sc. Survey Department, Cairo, Egypt. Government Press, Cairo, 1912. 4to; pp. xii + 394, with 27 plates and 62 text-illustrations. Price 40 piastres.

IT rarely happens that circumstances admit of a desert region being accurately mapped and studied in detail, since the economic importance of such parts of the world is usually very small. It is therefore fortunate for geologists and geographers that the demand for prospecting and mining licences in the south-eastern desert of Egypt, which arose about eight years ago, led to a survey which otherwise might never have been undertaken. A considerable number of points had to be located with such accuracy that the boundaries of any concessions which might be granted could be defined without the possibility of any ambiguity; at the same time as good a topographical and a geological survey were required as could be provided under the prevailing conditions. In the course of three winter seasons (1905–8), representing twenty-two months of field-work, Dr. Ball completed this work, and the results are presented in the volume before us. It is a notable contribution to the geology of North Africa, and one which presents many points of interest. All existing maps of the area were on small scales and of very inferior accuracy, so that a new survey covering about 22,000 miles has been carried out, and the results are given in an orographical map on the

scale of 1 : 750,000 and in a geologically coloured map on the same scale. These two taken together give an excellent picture of a region of which hitherto little has been known. As a result of this state of things a large part of this volume is taken up by detailed descriptions of the drainage systems, the hills and mountains, and the water supplies, which are mainly topographical but which contain a certain amount of geological information. A most valuable chapter treats of the special methods adopted in the survey to meet the conditions which prevailed, and this will repay careful study by all who may have to prepare their maps in hilly regions which are not largely timbered. Triangulation was extensively employed, and a very free use of vertical angular measurements furnished a very reliable representation of the relief of the region.

Sedimentary deposits are scantily represented by the coral reefs and raised beaches along the coast, the gypsum beds which occur on part of the coast, and the Nubian Sandstone which covers a considerable area in the western portion of the region. Besides these, alluvial deposits and accumulations of rock waste in the valleys and on the plains at the foot of the hills cover wide tracts, but igneous and metamorphic types of rocks form the surface over by far the larger part of this desert.

The igneous rocks fall broadly into two main divisions, one of an acid type represented by a granite rich in felspar, and the other of a basic type having gabbro for its representative. A few ultra-acid and ultra-basic rocks occur, while an intermediate division is also represented, but rocks of the granite and gabbro types predominate. The former occur largely as forming the higher mountains and dominant peaks, while the basic rocks form the lower hill-country.

Full descriptions are given of typical specimens from various localities, together with the special characters which microscopical examination brings to light. Volcanic rocks are comparatively scarce, and nothing like the wide occurrence which Dr. Hume has recorded in the north-eastern portion of this desert has been found by Dr. Ball in the south-eastern. Basic rocks predominate somewhat in the southern portion of this region, and rocks of the ultra-basic group, usually altered to serpentine, cover as much as 200 square miles of the desert.

Gneisses and schists cover very large areas, and the former constitutes some of the boldest scenery of the precipitous hills of the central portion of the range. Many ancient mining sites occur in this area, where the quartz veins have been worked for gold in the past, but in many cases they do not pay sufficiently to be worked under modern conditions. Besides the maps already mentioned, several plans on larger scales usefully supplement the text, while photographs of several mountain-summits and types of country illustrate the weathering of the rocks. The whole question of erosion and the development of the surface relief, for which Dr. Ball must have ample material, promises to be most interesting, and will doubtless be dealt with in due course. As it is, the present volume contains a very valuable account of a region offering many problems, for whose solution Dr. Ball has furnished important material.

A final chapter treats of the tectonic structure of the district and the possibility of the Eocene rocks and the Nubian Sandstone having had formerly a wider extension. In summarizing the past history of this part of Africa Dr. Ball suggests that the Red Sea depression originated between Upper Cretaceous and Oligocene times, and was increased in area by a sinking of the crust along its margin in Miocene times. The main drainage systems were, he thinks, initiated as early as the Oligocene period.

H. G. L.

III.—Geological Survey: Mineral Products of India.

A REVIEW of the mineral production of India during the year 1911 is given by the Director, Mr. H. H. Hayden, in pt. iii of vol. xlii of the *Records*. The method of classification is the same as that used previously, and we learn that the collecting of returns becomes more precise every year. A comparison of the total value of the minerals produced in 1910 and in 1911 shows an insignificant fall of half per cent. At the same time such important minerals as coal, gold, petroleum, and wolfram show a steady rise, the drop in the value of the total production being due to the curtailment in the output of manganese. The paper gives full tabular details of the mineral concessions granted during the year, and these show a good increase, this being due chiefly to the quest for wolfram in Lower Burma and for manganese in the Central Provinces.

The second paper in this part is by Dr. L. L. Fermor on "The Systematic Position of the Kodurite Series, especially with reference to the Quantitative Classification". Some three years ago Dr. Fermor described the series of rocks of which kodurite (composed of orthoclase felspar, a manganese garnet and apatite) is the type, but at the time he was unable to investigate its classificatory position. He has lately been able to investigate the matter, and has taken the opportunity of testing the methods of quantitative classification as set forth by Messrs. Cross, Iddings, Pirsson, and Washington. Dr. Fermor finds that these methods lack elasticity; on the other hand, he found no difficulty in fitting the kodurites in the classification adopted by Hatch, in which the Kotakarra kodurite may be called a manganshonkinite. One of the difficulties in the American system is the inability to deal with high Mn O. The author finds the 'norm' distinctly useful, however, and promises further discussion on this point when his investigations are complete.

IV.—Indian Desert Salt Deposits.

IN an interesting and highly important article on "The Origin of Desert Salt Deposits" Professor Sir Thomas H. Holland gives the results of his researches, aided by chemical analyses made by Dr. W. A. K. Christie, on the salt deposits of the Rajputana Desert (Proc. Liverpool Geol. Soc., xi, p. 227, 1912). It is pointed out that "Throughout the whole desert the subsoil water is

highly charged with sodium chloride, which is raised for the purpose of manufacturing salt at various places. The largest of the lakes is at Sambhar, which, when filled with water at the end of the rainy season, covers, according to the season, from 70 to 80 square miles, and with the latter area may reach a depth of only four feet in the centre of the lake". Since 1869 this lake has been "one of the principal sources of salt in Northern India, the output being on an average about 140,000 tons a year". About ten years ago it was thought that the resources of the lake might be diminishing, but investigations and borings made by the Geological Survey of India demonstrated "the occurrence of something like 54 million tons of salt in the uppermost 12 feet of silt", and anxiety was relieved.

After discussing various theories propounded with regard to the origin of the salt, Sir Thomas Holland points out that during the hot dry season large areas of the Rann of Cutch become covered with an incrustation of salt. During the same period, from April to June, dry, hot, and strong winds and gales blow from the south-west and carry away great quantities of the dry and powdery salt to the Rajputana Desert. When the rains set in the salt at and near the surface is carried in solution by the floods into the hollows which become temporary lakes, and after the rainy season is over there will be areas of concentrated brine, with or without complete evaporation, during a cold dry period. These conditions are succeeded by the hot season and by further supplies of salt-dust carried by the south-west winds. Observations and experiments carried on by Sir Thomas Holland and Dr. Christie have led them to conclude that at least 200,000 tons of salt are thus annually distributed over the Rajputana Desert.

Attention is drawn to the observations of the late J. Lomas on the features common to the Trias and to modern desert formations. Among these explanation is given of the occurrence of pseudomorphs of rock-salt and of the nature of the so-called red marls, which consist largely of very fine particles of quartz dust. It is noted that the silt of Sambhar consists locally of large accumulations of the finest mud of a deep-black colour, due to the presence of ferrous sulphide, and it is suggested that the red colour of the mudstones or so-called marls of the Trias are equivalent deposits, their colour being due to the subsequent oxidation of the iron-salt.

With respect to the bearing of wind-borne salt on estimates of geological time, the author supports the conclusions of Professor Joly and others concerning "the relative unimportance of such cyclic sodium in calculations regarding the rate of accumulation of salt in the ocean".

V.—Geological Survey of Western Australia.

IN Bulletin No. 45, 1912, Mr. H. W. B. Talbot deals with parts of "The North Coolgardie and East Murchison Goldfields", giving the results of a series of traverses made in company with Mr. C. S. Honman, the Topographical Surveyor. The report is illustrated by a geological sketch-map of the country around Lake Barlee (scale

4 miles to one inch), showing areas of granite, ferruginous quartz-schist, quartz reefs, and greenstones with undifferentiated metamorphic rocks (Auriferous Series). Some photographic views and sections are inserted in the text, and appended is a petrographical description of some rocks from the vicinity of Lake Giles, by Mr. R. A. Farquharson. The rocks comprise gabbro, epidiorite, amphibolite, etc.

Bulletin No. 46, 1912, contains "A General Description of the Northern Portion of the Yilgarn Goldfield and the Southern Portion of the North Coolgardie Goldfield", by Mr. Harry P. Woodward. The object of the report is to indicate those tracts of country to which prospectors are advised to devote attention, and also those to be avoided, such as certain large sand-covered granite areas. Information is given on the evidence to be gathered from the soils and surface features, and also on the important matter of water-supply.

Bulletin No. 50, 1912, is on "The Geology and Mineral Industry of Western Australia", by Mr. A. Gibb Maitland and Mr. A. Montgomery. This is a useful guide, giving a summary of what is known of the geological formations, and of the economic geology, included under the headings of gold, copper, lead, tin, tantalum, iron, coal, salt, phosphate deposits, and artesian water. Information is also given with regard to the mining and occupation of mineral lands.

VI.—Geological Survey of New Zealand.

"THE Geology of the Waihi-Tairua Subdivision, Hauraki Division" forms the subject of Bulletin No. 15 (new series), 4to, Wellington, 1912. The area, which is described by Dr. J. M. Bell (late Director) and Mr. Colin Fraser, constitutes part of the eastern coast of Hauraki, in the northern portion of the North Island of New Zealand.

With the exception of the superficial deposits the country is formed of a complex of volcanic rocks, which probably were extruded through a foundation of Jurassic or older rocks, none of which are exposed in the Waihi-Tairua Subdivision. The volcanic rocks form a series (1) of andesitic and dacitic lavas and breccias of Upper Eocene or Miocene age, (2) of somewhat similar but more fragmental materials and more glassy lavas of Miocene age, and (3) of rocks mostly rhyolitic, with dacitic tuffs, breccias, and lavas of Pliocene and perhaps later times. Many dykes of andesite and dacite pervade the lavas, and the rocks have been much altered by hydrothermal action. Among the rhyolites a brecciated flow-rock locally known as 'Wilsonite' is used as building-stone and road-metal.

Mining is the principal industry in the region, and the metalliferous areas of gold with silver appear to be limited to the Eocene and Miocene series (1 and 2). In the Waihi Gold-field the more productive part is within a large intrusion of dacite. Gold-bearing quartz-veins occur in the volcanic rocks. The first discovery of gold in New Zealand was made in 1852 in the Coromandel Subdivision to the north-west of the area now described. At Waihi the yield in 1910 was a little more than one million pounds worth of bullion.

Particulars are given of the methods of mining and treatment of ores, of the mineral veins and the conditions of the mineralized areas, the sinter deposits, and the underground waters, and there are detailed descriptions of the different mining areas and claims.

The greater portion of the area of volcanic rocks is hilly and mountainous, the highest elevation being that of Mount Kaitarakihi, 2,740 feet, and at one time the ground was covered by primeval forests, which have been much reduced by fires. The lower grounds are partly volcanic, as in the case of the Waihi plain, but are formed mostly by the fluviatile and estuarine deposits, the flood-plains constituting the chief arable lands. The coast is formed of precipitous cliffs with bays bordered by blown sands.

The volume is well illustrated by 10 plates of photographic views, 10 text-figures, and 18 geological and topographic maps, plans, and sections.

VII.—Textbook of Petrology. Vol. II. The Petrology of the Sedimentary Rocks. By F. H. Hatch and R. H. Rastall. With an appendix on the systematic examination of loose detrital sediments, by T. Crook. pp. xiv + 425, with 60 figures in the text. London: George Allen & Co., 1913. Price 7*s.* 6*d.* net.

THIS work is stated to be the second volume of a textbook on petrology, but the first has not yet appeared, unless it be Dr. Hatch's earlier book on petrology issued some few years ago by another publisher, and no mention is made of it in the preface. The present volume is concerned with the processes and changes through which sedimentary rocks have passed before they attained to the position and form in which they are found to-day. The subject falls naturally into two parts, the one dealing with the nature of the deposition and the other with the after metamorphic changes. That is the course followed by the authors in the present book, the second part being about half as long again as the first.

In the first chapter of the first part the authors discuss deposition in general, and proceed in the remaining three to enter more in detail into the three groups of fragmental, chemical, and organic deposits, into which sedimentary rocks may be grouped. Many of the deposits are of extreme interest and importance. For instance, the salt deposits are extensively worked, and those at Stassfurt in particular formed the subject of the classical researches by Van't Hoff and his pupils. Again, the nitrate deposits in Chili become increasingly necessary for agriculture, and their origin still remains a mystery, no completely satisfactory theory having yet been put forward. The coal deposits are, of course, of primary importance as the principal source of heat and power; the vexed question of their origin is touched upon.

The second part is devoted to the metamorphic changes that have taken place in the rocks after they were deposited, and successive chapters deal with metamorphism in general, cementation and metasomatism, contact metamorphism, regional metamorphism, and weathering. The particular subject applies to a considerable extent

to rocks in general, and would better have formed part of a general introduction to the whole work, if there is in truth to be a volume on the igneous rocks. The authors might have availed themselves of the space left free to discuss the classification of the sedimentary rocks.

Mr. Crook, of the Technological Department of the Imperial Institute, contributes an extremely valuable appendix on the systematic examination of loose detrital sediments. He has had some years of experience of the investigation of such material, and the hints that he is able to give will be welcomed by those with less experience and skill who may be faced with a similar task. Mr. Crook is a strong advocate of magnetic separation. An ordinary horseshoe magnet has, of course, long found a place in mineralogical laboratories for separating purposes in the analyses of rocks and meteorites, but by the use of an electromagnet he has elaborated a ready and useful method, which in conjunction with heavy liquids very speedily resolves detritus into its component mineral parts. The ordinary optical methods are referred to, and the general characters of the detrital minerals are summarized.

A good index brings the book to a close.

VIII.—Mineralogy. By A. H. Phillips. pp. x + 699, with 534 figures in the text. New York: The Macmillan Company, 1912. Price 16*s.* net.

REASONABLE in price and size, and well illustrated, the text-book on mineralogy written by Dr. Phillips, the professor of mineralogy at Princeton University, may safely be commended to the use of students who, while not wishing to specialize in crystallography or mineralogy, desire to acquire sufficient working knowledge of these subjects to enable them to determine the minerals, whether megascopic or microscopic, constituting the rocks which they may happen to be investigating. The author has successfully contrived to avoid unnecessary abstruseness without sacrificing lucidity or slurring over difficulties.

The book is divided into three parts, viz. Crystallography, Descriptive Mineralogy, and Determinative Mineralogy, of which the second is about as long as the other two together. The author considers at some length the morphological characters of crystals, and makes use of Miers' nomenclature for the classes of crystalline symmetry. Twinning and parallel growths are amply treated in the chapter on the relation of individual crystals. The measurement of crystals and the use of the goniometer are somewhat perfunctorily dealt with, but the optical properties are fully and clearly discussed. Chapters on the other physical characters, such as cleavage and fracture, specific gravity and its determination, structure, colour, streak, lustre, phosphorescence, and fluorescence, and on the relation of minerals to the elements, and the origin of minerals are included in the next part. The description of the principal mineral species, which takes up the bulk of the second part, is well arranged. Under each species are given its chemical and physical properties, the nature

of its occurrence, and its use, and illustrations of typical crystals or specimens are in many cases included. The third part will be found of great practical use. It includes descriptions of the apparatus and reagents required for blowpipe work and simple chemical tests and a series of useful tables. A well-arranged index enhances the value of the book.

IX.—Volcanoes: their Structure and Significance. By T. G. Bonney, Sc.D., LL.D., F.R.S., Emeritus Professor of Geology at University College, London. Third edition. 8vo; pp. 379, with 16 plates and 21 text-illustrations. London: John Murray, 1912. Price 6*s*. net.

THIS volume, issued in a fiery red cloth, has evidently met with approval from the "ordinary reader" to whom primarily it is addressed. Success is indicated by the fact that a third edition has been required in the course of fourteen years. The work, indeed, is written in what may be called a fairly popular style, technical terms being avoided as far as possible, and a short glossary of some of those applied to minerals and rocks being appended.

In chapter i the life-history of volcanoes is explained by reference to Vesuvius, Stromboli, Bandai-san in Japan, Krakatoa, the Soufrière of St. Vincent, Mont Pelée in Martinique, Cotopaxi, Kilauea, and Mauna Loa, and the subject is illustrated by some good views, including one of the great 'spine' of Mont Pelée. Submarine eruptions, mud volcanoes, and geysers are described, but we miss a reference to the submarine formation of pillow-lavas.

In chapter ii the structure and classification of igneous rocks receive attention, and illustrations are given of volcanic dust, pumice, lava, bombs, and the columnar jointing of basalt. Then follow, in chapter iii, accounts of the dissection of volcanoes, naturally illustrated in the regions of Auvergne and the Eifel, from which latter district a striking view is given of the crater lake, Weinfelder Maar. The subject leads on to that concerning the ruins of more ancient volcanoes, among them Arthur's Seat at Edinburgh. Here differences of opinion have been expressed, but we may question now whether "the majority of geologists maintain that there were two distinct epochs of outbursts". In the Geological Magazine for 1911 (p. 133) it was noted, in a review of the Geological Survey Memoir on Edinburgh (second edition), that the re-survey of Arthur's Seat led to the confirmation by the Survey of the final views of Maclaren and the conclusions of Professor Judd, that but one period of volcanic activity was represented. A reference to this might have been given, as the author expresses himself in favour of the belief that the outbreaks "were separated by a very considerable interval of time".

Fissure eruptions are dealt with in reference to volcanic mountains where great outbursts take place, and also to those areas, such as the Snake River plain in Idaho, that "are characterized by the general absence of cones", and by the large extent of land covered by lava-flows.

In chapter iv is given a brief account of the geological history of British volcanoes. Here some advances have been made since the publication in 1897 of Sir A. Geikie's great work on the subject, to which the author rightly gives prominence. At Brent Tor lavas of Upper Devonian and Carboniferous age are now recognized by the Geological Survey (*Geology of Tavistock*, etc., 1911, p. 51); Mr. Harker's views on the Sgùrr of Eigg might have been explained a little more fully than in a footnote, and his researches on the Tertiary igneous rocks of Skye should have been mentioned by the author when dealing with the controversy between Professor Judd and Sir A. Geikie. He need not then perhaps have abstained from any expression of opinion on the matter.

Chapter v, on the distribution of volcanoes, is followed by a final chapter on the theories of volcanoes. Here, as in the previous criticisms we have ventured to make, we must bear in mind the author's reminder that his "aim in writing has not been the examination room". At the same time he has left some of his general conclusions as they were written for the first edition in 1898, though admitting that "since then important advances have been made". In treating of the origin of volcanoes he alludes to earth movements as probably "potent agents in causing molten rock to change its position"; he maintains that the expansive form of steam is "a prime factor in the explosive phenomena", and that though much of the water may have been added at a late stage in the history of an eruption, "yet water may also have been present in the magma from the very first, or may have gained access to it at a much earlier stage in its history." While referring to Dr. A. Brun's view that water plays but a small part in the explosive phenomena of volcanic eruptions, reference should have been made also to the important volume on *The Natural History of Igneous Rocks*, by Mr. Harker (1909), who argues that there is sufficient water in the deep-seated molten rocks to explain the aqueous phenomena displayed in volcanic eruptions. Nevertheless, we agree with the author that it is difficult to account for the phenomena "without supposing a marked and local increase of the water originally present in the magma".

X.—Earthquakes.

THE Bulletin of the Seismological Society of America (vol. ii, No. 3, 1912) contains, among other articles, an historical account of the "Great Earthquakes in the Island of Haiti", by Mr. J. Scherer. Particulars relating to "The Hawaiian Earthquakes of 1868" are given by Mr. C. H. Hitchcock, now a resident at Honolulu. The disturbances have occurred in association with eruptions from Mauna Loa and Kilauea, and it is pointed out that there is a sympathetic connexion between the two volcanoes. Although the lava from one issues at an altitude of 12,000 feet and from the other at 3,500 feet, synchronous eruptions have taken place when the pressure of lava was most potent, and they have been accompanied by strenuous earthquakes. In the light of present knowledge, Mr. Hitchcock states that the chief events in the history

of the volcanic displays are as follows: (1) illumination over Mauna Loa, (2) earthquakes, (3) discharge from Kilauea, (4) landslide, (5) great sea-waves, (6) eruption and flow of lava from near Mauna Loa to Kilauea. In 1868 the lava gushed out from an elevation of 5,600 feet and along an earthquake fissure a mile in length, that coincided in the lower part of its course with the western edge of the plateau. It is remarked that the earthquakes belong to the class denominated volcanic rather than tectonic, and that from the destructive effects of the latter Hawaii is immune. The quaking is produced by the passage beneath the surface of lava which is endeavouring to escape. Eventually vertical fissures are formed, and the lava wells out. In another paper Mr. A. C. Lawson gives a description with illustrations of "Recent Fault Scarps at Genoa, Nevada".

XI.—Ground-water and Springs.

Grundwasser und Quellen. By Dr.h.c. Hans Höfer von Heimhalt. pp. xi + 135, with 51 figures in the text. Braunschweig: Friedr. Vieweg & Sohn, 1912. Price 4 marks.

THE provision and maintenance of a plentiful supply of good drinking water is a question of primary importance to the inhabitants of every town or city, or any place where men crowd closely together, and a satisfactory answer to it calls for the aid of the chemist to test the purity of the water, and of the engineer to pump and convey it, and, in the first instance, of the geologist to determine the best and most suitable source of the desired supply. We must not forget, too, that springs which are not ordinarily potable may have valuable medicinal uses. The subject is one that lies somewhat outside the scope of ordinary textbooks on geology, and Dr. Höfer von Heimhalt has by this book met a distinct gap in scientific literature; the treatment, while adequate, is simple in style, and the avoidance of unnecessary technicality renders the book suitable to a wide circle of readers.

The book opens with a short section on the hardness of water and the factors which govern the suitability of water for drinking purposes. The next deals with the more or less devious paths by which the moisture present in the atmosphere ultimately finds its way by condensation and infiltration underground in the shape of water, and the author points out how large a part mountains play in feeding the underground supply by causing an ample precipitation of moisture. In the third section he discusses at some length the various types into which underground water may be classified according to the formation of the strata carrying it, and the change produced in the water-level by steady pumping. Incidentally the danger of removing water from an unstable sand layer is emphasized; a danger, moreover, that has to be reckoned with even when the object of the boring is not water, but one of the shallow or deep tunnels with which we are so familiar in London. The excellent diagrams with which the text is liberally illustrated show clearly that, although haphazard well-sinking may often be successful in

finding water, yet to get the best results proper study of the stratigraphical geology of the district is essential. Mineral and hot springs and the causes of the mineralization and the elevation of temperature are considered at the close of the book. Altogether the work is one that we may confidently recommend to all interested in hydro-geology. The absence of an index, however, is to be deplored.

XII.—Glasgow Geological Society.

THE Transactions of this Society for 1911–12 (vol. xiv, pt. iii, 1913) contain a paper by Professor J. W. Gregory on "The Polmont Kame and on the Classification of Scottish Kames". The Polmont kame extends for a length of about 4½ miles, from Callendar Park, near Falkirk, to the south of Bo'ness High Junction Station. It is composed of water-worn gravel, has a general width of 10 to 40 yards at the base, rises from the adjacent ground from 10 to 50 feet, and slopes at angles of from 15° to 25°. It rests on the main Boulder-clay of the district, and was probably formed at the same time as the Boulder-clay of the drumlins to the north. The author regards the Polmont ridge as a marginal deposit, formed by the wash of water down an ice-slope, and not fluvio-glacial as in the case of eskers and certain of the Scottish kames; and he describes the Polmont kame as 'glacieluvial', a term suggested by Professor Phillimore.

Mr. G. W. Tyrrell gives an account of "The Petrology of the Kilpatrick Hills, Dumbartonshire; with notes on the Scottish Carboniferous Basalts". He also describes some "Variolites from Upper Loch Fyne and Skye". Mr. W. R. Smellie deals with "The Sandstones of the Upper Red Barren Measures to the east of Glasgow", strata which overlie the Productive Coal-measures; he describes the mineral constituents of the rocks and the conditions under which they were deposited, and gives a good view of spherulitic jointing in sandstone.

Among other papers is one "On the Distribution of *Posidonomya corrugata*, Ether., jun., in the Carboniferous Limestone of the Glasgow District", by Mr. Peter Macnair and Mr. H. R. J. Conacher.

XIII.—Brief Notices.

1. The Journal of the Washington Academy of Sciences, January 19, 1913, gives the result of Dr. H. E. Merwin's investigations in searching for liquids of high refraction which would be suitable for the determination of minute grains under the microscope by the Becke or similar method. Mixtures of methylene iodide with tin and arsenic iodides and sulphur give liquids ranging from 1·764 to 1·868, and by dissolving arsenic sulphide in methylene iodide 2·28 may be reached. He also describes reliable melts which may be used in the same way: arsenic and antimony iodides dissolved in piperine, 1·68–2·10; sulphur with arsenic sulphide, 2·1–2·6; piperine with rosin, 1·546–1·682; rosin with camphor, 1·510–1·546.

In the same Journal, January 4, 1913, Dr. F. E. Wright describes a simple accessory to the vertical illuminator used in the microscope, which enables the observer to produce apertures of any desired size in any part of the field, and at the same time to eliminate disturbing rays.

2. In the American Journal of Science, 1913, vol. xxxv, pp. 63–82, Dr. F. E. Wright discusses the methods available for producing oblique illumination in the petrological microscope, and recommends the use of either a sliding stop in the lower focal plane of the condenser, or placing the index finger below the condenser and observing the edge of the shadow cast by it. He proceeds to consider the utility of the method in the determination of relative refractive indices, and points out that the interference phenomena between crossed nicols in oblique illumination and in convergent light are precisely similar. Incidentally he draws attention to a useful field method of distinguishing between calcite and dolomite. The powdered mineral is placed in a drop of monobromonaphthalene between two glass slips and studied with a lens in oblique illumination. In the case of calcite the grains have coloured fringes.

3. In the Proceedings of the United States National Museum, vol. xliv, Mr. G. P. Merrill describes the meteoric stone found in 1911 near Cullison, Pratt County, Kansas, and said to have fallen there on December 22, 1902. The mass, which weighs 10·10 kilograms, is now in the United States National Museum. It is so dense and fine-grained that it resembles a weathered boulder of a trappean rock, but an examination of a thin section at once revealed its true character. The meteorite has an interesting chondritic structure, and shows signs of brecciation. It probably formed part of a much larger mass.

4. Chilean Borate Deposits. — Mr. R. T. Chamberlin discusses "The Physical Setting of the Chilean Borate Deposits" (*Journ. Geol.*, Chicago, xx, p. 763, Nov.–Dec., 1912). He points out that throughout the extent of the great plateau, which rises from 12,000 to 13,000 feet above sea-level in Chile, Bolivia, and Peru, there are numerous lakes, saline marshes, and beds of former lakes, mostly with no outward drainage. The large lakes of Titicaca and Pampa Aullagas are well known, but there are many minor lake-flats, dry or nearly so, which escape notice. It is on some of these old lake-bottoms that the great borate deposits of South America occur; but it is significant that the lacustrine tracts which contain borax, mostly lie close to the volcanoes of the Western Cordillera. Away from the volcanoes, whether eastward over the central plateau, or westward down the long desert-slopes leading towards the coast where the nitrate beds abound, the borates rapidly disappear. They thus seem to be related to the volcanoes. The nitrates occur on open salinas at less elevations, 3,000 to 5,000 feet. The borax fields are located high up on the edge of the tableland close to the base of the big volcanoes. Both nitrates and borates are dependent for their accumulation and preservation upon the extreme aridity of the region.

5. Rothamsted Experimental Station, Harpenden. — In his Annual Report for 1912, the Director, Dr. E. J. Russell, remarks in connexion with researches on soils: "Our new conception is that the soil organisms may be divided roughly into two groups in their relation to the processes of food production: a useful group and a detrimental group. The latter are, speaking generally, more readily killed than the former. Conditions that are harmful to active life in the soil tend therefore to reduce their numbers, and lead to an increased activity of the useful bacteria. On the other hand, conditions favourable to active life tend to keep up the detrimental organisms, and therefore to reduce the useful bacterial activity. We have thus been able to render intelligible a number of obscure and paradoxical effects that have hitherto caused considerable perplexity. It has already been observed by practical men in various countries that certain soil conditions harmful to the growth of organisms were ultimately beneficial to productiveness: such are long continued and severe frost, long drought (especially if associated with hot weather), sufficient heat, treatment with appropriate dressings of lime, gas lime, carbon disulphide, etc. Further, it has been observed that conditions which are undoubtedly favourable to life, such as the combination of warmth, moisture, and organic manures found in glass houses, lead to reduced productiveness after a time."

REPORTS AND PROCEEDINGS.

Geological Society of London.

(i) *April* 9, 1913.—Dr. Aubrey Strahan, F.R.S., President, in the Chair.

The following communications were read:—

1. "The Variation of *Planorbis multiformis*, Bronn." By George Hickling, D.Sc., F.G.S., Lecturer in Palæontology and Demonstrator in Geology in the Victoria University of Manchester.

The writer gives an account of an investigation of the above-named Miocene Gasteropod, based on a suite of 532 specimens from a single block of stone. The shells of this type from the Steinheim deposits were formerly investigated by Steinmann, Hilgendorf, Hyatt, and others. Many species and sub-species were founded by those writers, who also constructed genetic series which were described as following a stratigraphical sequence. The specimens considered in the present paper include several of the species and sub-species of Hyatt. Since, however, these individuals were clearly all living together, and all the types appeared to pass one into the other by insensible gradations, it seemed doubtful whether they could properly be regarded as constituting more than a single species. Accordingly a study was made of the variation in height presented by the shells, which include every gradation between perfectly discoid forms and types with a spire the height of which considerably exceeds the diameter of the base. By sorting the whole of the shells into ten grades, according to height, it was shown that forms of mean height were

common, while extreme forms were rare, the height being distributed, in fact, according to a typical 'variation curve'. If more than one species were really present, it is in the highest degree improbable that the various types should be distributed in the proportions actually found, and this is taken as the most satisfactory proof possible of the specific unity of the group.

It is shown that the shells also vary extensively in respect of the amount of carination, the degree of involution, the form of cross-section of the whorls, the form of aperture, and the stage of development at which various characters are acquired, the variation in each character being, however, 'continuous.' The ontogeny of the various characters is considered, and the species is shown to be highly variable at an early stage, the mature characters being largely independent of early variations.

A discussion is given of the bearing of the inquiry on the stratigraphical application of palæontological data.

2. "The Structure and Relationships of the *Carbonicolæ*." By Miss M. Colley March, M.Sc. (Communicated by Dr. G. Hickling, F.G.S.)

The evidence for the relationship of the *Carbonicolæ* to the Unionidæ, based on shell-structure, muscle-scars, form, habitat, ligament, and hinge-teeth appears insufficient. The first five of these characteristics are shared with obviously unrelated groups. With regard to the last—the teeth—as seen in developed specimens and reconstructions from sections, they seem to be absent. The hinge-apparatus appears to consist of a cardinal plateau, grooved for the reception of an internal ligament. The hinge-plate and ligamental groove are absent in *Carbonicola antiqua*, very poorly represented in *C. turgida* and similar forms, and most highly developed in *C. aquilina*. Another fact which argues against the relationship of the Unionidæ to the *Carbonicolæ* is the absence of ornament in the latter group and its presence in the former. This holds good whether the ornament is considered to be due to the effect of the glochidial hooks in the young shells, or to be the remains of ornament; because in the former case it implies the absence of the glochidial stage, and in the latter it implies descent from an unornamented ancestry.

The position of the *Carbonicolæ* appears to be unsettled, and to be possibly quite different from that of any of the Pelecypoda yet studied; because, according to Bernard's work, the cardinal plateau is developed subsequently to the hinge-teeth, while in the *Carbonicolæ* it is acquired independently of them, specialization taking place in the ligament, for the reception of which the plateau is developed and specialized.

(ii) *April* 23, 1913.—Dr. Aubrey Strahan, F.R.S., President, in the Chair.

Professor E. Hull described the large chart of the North Atlantic Ocean which was hung on the wall. This chart had been prepared to illustrate the paper which he had read at the meeting of the International Zoological Congress held at Monaco in March, to show the mode of migration of animals by land-connexion between Europe

and the American Continent, due to the great uplift of the whole region by several thousands of feet during the Mio-Pleistocene Epoch. The chart showed at a glance the submerged structure of the ocean-bed and bordering coasts on both sides of the ocean, indicating a rise of 1,000 to 1,200 fathoms (6,000 to 7,000 feet) during the culminating stage of the Glacial Period. This was proved by the fact that the channels of the existing rivers—such as the Loire, the Adour, the Mondego, the Tagus, and the Congo—were continued down to the depths above named, across 'the Continental Platform' and 'the Great Declivity' to the floor of the Abyssal Ocean. The details had been worked out by means of the soundings taken from the Admiralty charts and the isobathic contours, the details of which are recorded, with the charts appertaining thereto, in the speaker's *Monograph of the Sub-Oceanic Physiography of the North Atlantic Ocean*. In the view of the speaker this great uplift of the Northern Hemisphere was the *vera causa* of the Glacial Period or 'The Great Ice Age' of Professor James Geikie.

The following communications were read:—

1. "On the Fossil Flora of the Pembrokeshire Portion of the South Wales Coal-field." By Reginald H. Goode, B.A. (Communicated by Dr. E. A. Newell Arber, M.A., F.G.S.)

Of the fifty-three determinable species of fossil plants obtained from the Pembrokeshire portion of the South Wales Coal-field, three are new species. One may be referred to *Linopteris brongniarti*, Gutb., a plant which has not with certainty been found before in Britain.

From the palæobotanical evidence it is clear that the so-called 'Pennant Grit' of Pembrokeshire cannot be regarded as the equivalent of the Pennant Grit of the main portion of the South Wales Coal-field, for the plants indicate that these beds are Middle Coal-measures, and do not belong to the Transition Series. The Lower Coal Series also clearly belongs to the Middle Coal-measures; and the Settlings Beds, and perhaps the Falling Cliff Beds as well, lie probably at a higher horizon than the Lower Coal Series as developed farther east along the Saundersfoot coast, and even possibly higher than the Timber Vein group.

Until more plants have been obtained from the so-called 'Millstone Grit' of Pembrokeshire, it is impossible to fix definitely the horizon of these beds from the palæobotanical evidence. However, from the fossil plants obtained in the so-called 'Millstone Grit' of Monkstone Point, and in neighbouring beds belonging to the Lower Coal Series, between which there is no apparent unconformity, it is evident that these particular beds, assigned to the Millstone Grit, probably belong to the Middle Coal-measures.

When the fossil plants which have been obtained from the Pembrokeshire Coal-field are compared with those which have been recorded from the main South Wales Coal-field, it is evident that there are considerable differences in the occurrence of the species.

Thirty-two fossil plants have been obtained from the Middle Coal-measures of Pembrokeshire which have not as yet been recorded from those of the main South Wales Coal-field, and hence are additions to

our knowledge of the flora of the Middle Coal-measures of South Wales.

2. "The Halesowen Sandstone Series of the Southern End of the South Staffordshire Coal-field; and the Petrified Logs of Wood found therein at Witley Colliery, Halesowen (Worcestershire)." By Henry Kay, F.G.S. With an Appendix on the Structure of a New Species of *Dadoxylon*, by E. A. Newell Arber, M.A., Sc.D., F.L.S., F.G.S.

The Halesowen Sandstones are separable from the Old Hill Marls by a series of passage-beds consisting of conglomerate bands, marl bands, and ironshot sandstones.

At the summit of the series is Professor Charles Lapworth's "*Spirorbis* Limestone Group", which is renamed the "Illey Group" in consequence of the discovery of *Spirorbis* limestone at other horizons.

The Halesowen coal-seam and associated beds of blue clay form a definite intermediate horizon traceable across the coal-field. On this is based a classification consisting of—

	Thickness in feet.
(5) The Illey Group	100–120
(4) The Hasbury Group	120–150
(3) The Halesowen Coal and Clays	10–50
(2) The Witley Group	200
(1) The Passage Beds	0–100

The area is folded into two anticlines with a deep central syncline ranging south-south-eastwards, and the strata have a persistent south-south-easterly dip. The northern face is let down by a fault repeating the lower beds. Other faults throw southwards, and yet others intersect the anticlines. Unconformities occur at the base and at the summit of the Hasbury Group in the Wassel Grove area, the former being largely buried by horizontal members of the group. Mining operations show the existence of a buried anticline with the full Coal-measure Series, but cutting out successively the Old Hill Marls, the Passage Beds, and a great part of the Witley Group. This is cut off by a fault only from the exposed Netherton Anticline immediately on the north, the uprise of which in early Upper Carboniferous time is therefore inferred.

The Keele Beds rest unconformably near the buried anticline upon the Illey Group, and upon various members of the Hasbury Group, and are themselves much reduced in thickness. Additional uplift of the anticline in later Upper Carboniferous time is suggested as the cause.

The Witley Colliery railway-cutting shows big logs of petrified wood very finely preserved by calcite, and indisputably of Upper Carboniferous age. The wood has been examined by Dr. Newell Arber, who finds it to have Araucarian affinities, but of a species new to science. In consequence of its Palæozoic age, it is referred to the genus *Dadoxylon*. The type of preservation is also new to this horizon in this country, and the discovery of *Dadoxylon* at Witley constitutes a new record for British Upper Carboniferous rocks. Among the associated plants are *Calamites*, *Lepidodendron*, etc.

(iii) *May* 7, 1913.—Dr. Aubrey Strahan, F.R.S., President, and afterwards W. Whitaker, B.A., F.R.S., F.G.S., in the Chair.

The following communications were read:—

1. "The Bathonian Rocks of the Oxford District." By M. Odling, M.A., B.Sc., F.G.S.

In this paper the author describes the lithology, palæontology, and stratigraphy of the Bathonian rocks north of Oxford, from the evidence afforded by numerous quarries and well-borings and by the Ardley Cutting on the Great Western Railway (new Birmingham main line).

The general sequence is as follows:—

		Thickness in feet.
CORNBRASH.	Rubbly non-oolitic limestone, with occasional marl bands	8–17
	Slight unconformity.	
FOREST MARBLE.	Coarse shelly and oolitic limestones largely false-bedded. When traced eastwards the limestones are largely replaced by marls; and finally the series is represented by green and blue clays with minor bands of limestone	21
	Well-marked unconformity.	
GREAT OOLITE.		
	Block 1.	
	Compact, fine-grained, pure limestones, with a local blue or green clay about the centre. The variation in thickness is largely due to erosion	7–13
	Well-marked eroded surface.	
	Block 2.	
	Compact limestones of a coarser texture than those of Block 1. The full thickness is exposed only in the Ardley Cutting, where it is 15 feet. The thickness to the base of the '*Nerinæa* Rock' is about 6 feet at Ardley and 17 feet in the Gibraltar Quarry, 3 miles away to the south-west	—
	Block 3.	
	Clays and sandy argillaceous limestones, now exposed only in the Ardley Cutting	7½
FULLONIAN.		
	Upper Beds.	
	Compact rock and clay, very fossiliferous	5
	Fullers' Earth Rock	4
	'*Concinna* beds'	4½
	(Position of the Stonesfield Slates.)	
	Lower Beds.	
	'Neæran Beds,' consisting of a series of semi-estuarine green clays, with one band of limestone about the centre	about 16
	Chipping Norton Limestone, consisting of sandy and argillaceous limestones	12

After a general description of the series, the principal points of interest in the different sections and their mutual relations are described; and the author points out that, although no definite zones

can be formulated, the different horizons are readily recognizable by their assemblage of fossils.

The chemical and microscopic structure of the rocks is dealt with, and the conditions of deposition and stratigraphical relationship of the different members of the series are discussed. In addition, some peculiar structures from the Chipping Norton Limestone are described, and the author adduces his reasons for considering them to be annelid tubes.

A complete list of the fossils is appended, showing the horizons and exposures from which they have been obtained; tables giving the correlation between different exposures are also added.

2. "On the Petrology of the Kalgoorlie Goldfield (Western Australia)." By James Allen Thomson, M.A., D.Sc., F.G.S.

The district described comprises an area about four miles long by one mile in breadth. Towards its southern end the auriferous lodes are very rich (The Golden Mile), but in the northern end they are not so productive. The information as to the geological structure has mostly been obtained from mining plans, shafts, and workings. The rocks have a general north-north-westerly strike, and most of the junctions are faulted. In "The Golden Mile" the central feature is a boss or broad dyke of quartz-dolerite, which forms a prominent ridge flanked by amphibolites and greenstones. The quartz-dolerite is cut by dykes of albite-porphyry, and west of the main ridge similar porphyries are frequent. Gold is found principally in shear-zones, impregnated with sulphides and tellurides, and is most abundant in the lodes of the quartz-dolerite.

The rocks for purposes of description are divided into—

(A) Sedimentary.—Of these the most distinctive are conglomerates and grits, the former containing pebbles of quartzite and of albite-porphyry.

(B) Igneous.—These are often very highly altered by metamorphism (inducing schistosity and partial recrystallization) and by metasomatic action. They include—

(1) Fine-grained amphibolites; altered basic igneous rocks—probably lavas and tufts.

(2) Fine-grained greenstones; slightly schistose aggregates, probably related to the fine-grained amphibolites in origin.

(3) 'Calc-schists': whitish-green rocks, which are closely connected with the greenstones and merge into them.

(4) Peridotites, serpentines, etc., often filled with carbonates, but perhaps comprising originally enstatite-peridotites as well as other types. These rocks form the eastern part of the northern end, and include talc-magnesite rocks and fuchsite-magnesite rocks.

(5) Hornblende-rocks or pyroxene-amphibolites, probably occurring as dykes in the peridotites.

(6) Lustre-mottled amphibolites, containing remains of felspar, and originally hornblende-dolerites.

(7) Epidiorites, uralitized and saussuritized gabbros or ophitic dolerites, not very numerous.

(8) Quartz-dolerites and their derivatives—amphibolites usually coarse-grained, with a considerable amount of interstitial micropegmatite. This is the important rock of 'The Golden Mile'. It contains very coarse pegmatitic veins, and is often to a great extent albitized. It presents a great variety of types due to different stages and kinds of alteration, and many of these phases are difficult to recognize as derived from the quartz-dolerites.

(9) Albite-porphyrites (with hornblende and biotite) and albite-porphyries. Secondary minerals are common in the rocks of this group.

(10) Jaspers and graphitic schists. These traverse all the other rocks, occurring as lodes or bands, and may closely resemble sedimentary schists. They sometimes are found running on each side of dykes of albite-porphyry. Their mode of origin is not quite certain, but they are intimately connected with the igneous rocks.

The relation and the sequence of the rocks of Kalgoorlie are next discussed.

The greenstones, fine amphibolites, and calc-schists are regarded as the old 'country rocks', into which the others are intrusive. They are probably a complex of basic lavas, ashes, etc., greatly altered.

The quartz-dolerites, hornblende-dolerites, and pyroxenites are very closely related one to the other, and show every grade of transition. Probably the peridotite group is merely the early basic facies of the quartz-dolerite series, and the porphyries and porphyrites, which were the last rocks intruded, are regarded as being derived from the same magma.

The metasomatic changes and origin of the ores are then considered. The great characteristic of this gold-field is the prevalence of albitization in the auriferous districts. From this, and from a general consideration of the rock-facies developed from the magma, it seems probable that we have in Kalgoorlie an instance of the production of auriferous lodes by rocks belonging to the same class as the pillow-lavas and their diabases and soda-granite-porphyries (the spilitic suite of igneous rocks).

The paper contains a large number of chemical analyses, principally carried out by the chemists of the Geological Survey of Western Australia. By the kindness of the Director of that Survey the author has also been able to make use of the specimens in the Survey cabinets, in addition to those collected during his own examination of the gold-field.

CORRESPONDENCE.

GRANITE AND CRITICAL TEMPERATURES.

Sir,—I have to thank Dr. Johnston-Lavis for two reprints, and especially for a marked list of 161 of his papers.

As my critical-temperatures inquiry has been confined to low-temperature plutonic rocks, down to their associated quartz-veins in adjacent sedimentary rocks, I cannot discover how I have in any way invaded Dr. Johnston-Lavis' field of work, either for agreement or dissent. There is no issue between us. His temperatures are far above the critical temperature of water, mine are almost entirely below it.

With respect to the possibility of granite cavities and fissures at great depths, which Dr. Johnston-Lavis denies, Sir T. H. Holland, in the Magazine for last month, cites Professor F. D. Adams as having proved that empty cavities can exist in granite under pressures equivalent to a depth of at least 11 miles, and at still greater depths if filled with liquids (Geol. Mag., 1913, p. 170).

Once-fissured granite is quite common, re-compacted by invasion of later granitic material. This is the fact, whether theoretically possible or not.

A. R. HUNT.

SOUTHWOOD, TORQUAY.
May 5, 1913.

THE RAISED BEACHES OF TORBAY.

SIR,—Mr. Jukes-Browne's somewhat splenetic, chiefly personal, and wholly unexpected attack reminds me of the notice in the American saloon: "Do not shoot the performer. He is doing his best." As a raised-beach performer I enjoy, or once enjoyed, the very small distinction of having presented to geologists the longest list of shells recorded from any single British raised beach. I have therefore been much interested in the subject, and have endeavoured to keep myself abreast of recent discoveries.

Mr. Jukes-Browne, so far as I know, has never done a day's work on beach or raised beach. His attack is easily disposed of. To save space I will employ parallel columns.

A. J. J.-B., 1913.	A. R. H., 1903.
"Apparently he [Mr. Hunt] has not realized that the whole question of the age of the raised beaches of Devon and Cornwall has entered an entirely new phase since the discovery that the raised beach of Gower (in South Wales) is older than the local glacial deposits."—GEOL. MAG., 1913, p. 236.	"Mr. Tiddeman's evidence of the glacial age of the Raised Beaches of the Gower Peninsula has reopened the whole question of the Raised Beaches of the south-west of England."—TRANS. DEV. ASSOC., 1903, p. 318. I was present when Mr. Tiddeman read his paper on September 11, 1900.
A. J. J.-B., 1913.	Professor E. HULL, 1913.
"The beaches testify to a subsidence which culminated either just before or during the epoch of maximum glaciation."—TRANS. DEV. ASSOC., 1913, p. 726.	"The chart . . . indicating [for Europe and the North Atlantic] a rise of 1,000 to 1,200 fathoms (6,000 to 7,000 feet) during the culminating stage of the Glacial Period."—PROC. GEOL. SOC., 1913, p. 88.
A. J. J.-B., 1913.	A. R. H., 1904.
"I have discovered what Mr. Hunt meant by . . . a Neolithic flint '*at Hope's Nose*'."—GEOL. MAG., 1913, p. 238.	"The mere fact of the discovery of Neolithic *flakes* newer than the adjacent beach at Hope's Nose, Torbay, may be worth a bare record."—GEOL. MAG., July, 1904. There was nothing concealed, so nothing to be discovered.
"He [Mr. Hunt] indicates three lines of evidence, viz. those of flint implements, Molluscan fauna, and geographical position."—GEOL. MAG., 1913, p. 237.	"Geology, geography, conchology, physics, palæontology, archæology, anthropology, and even micro-petrology [I forgot spelæology, zoology, and chemistry], all seem to incline towards the conclusion," etc.—GEOL. MAG., 1913, p. 107. I never referred to 'implements'; and there are ten lines of evidence, not three.

When, some time ago, I consulted two imaginary charts, by Mr. Jukes-Browne, of Pleistocene times,[1] I found that in neither did the sea approach the Torbay raised beaches! A sea-beach without a sea is impossible.

Mr. Lamplugh, in the current number of the GEOLOGICAL MAGAZINE, seems to have exactly defined the present position of this raised beach question. He observes that "the correlation has still an element of uncertainty".[2] That is all I at present maintain, viz., that the age of these Torbay beaches has *not* been "fairly well settled".

If Mr. Jukes-Browne can justify his charge, by reference to any passage of mine in the GEOLOGICAL MAGAZINE (since 1890), that I am a "needless fault-finder", I will give £5 to any hospital or to any scientific object that you, Sir, may kindly indicate.

A. R. HUNT.

SOUTHWOOD, TORQUAY.
May 3, 1913.

THE 'CRETACEO-TERTIARY' OF NEW ZEALAND.

SIR,—I noticed that in the November number of the GEOLOGICAL MAGAZINE there was a further criticism of my work on the younger rock system of New Zealand. At this distance it is, I think, inadvisable to detail at great length the exact features of local stratigraphy. This I intend to do in the pages of the Transactions of the New Zealand Institute, the publication in which my first article on this subject appeared. I hope, however, that you will find space for a reply on a few of the more general aspects of the question.

1. Insistence is laid on the fact that below the Oamaru Limestone Cainozoic fossils only have been found, while beneath the Amuri Limestone Cretaceous fossils occur. As a matter of fact, in all those districts where the Amuri Limestone has been found there is a thickness of 500 to 2,000 feet of strata that have up to the present time yielded no fossils, while the Amuri Limestone itself is almost destitute of fossils, though those that have been found are of Tertiary aspect.

The explanation that I have put forward, viz. continuous rapid depression until after the deposition of the limestone, makes it evident that in off-shore and in relatively low-lying localities the deposition of limestone would commence far earlier than in localities that were submerged only slightly before the climax of depression. The thick deposits of foraminiferous ooze which is the nature of the Amuri Limestone must, therefore, represent not merely in its upper part the same horizon as the Oamaru Limestone, but in its lower part a considerable thickness of subjacent beds, be they conglomerates, greensands, or mudstones. One may add, too, that the latest critical statement (1892) of Tate classes the Echinoderms of the Oamaru Limestone (twenty-six species, all extinct) as Eocene with a Cretaceous complexion.

[1] *The Building of the British Isles*, 1888, pp. 294, 300.
[2] GEOL. MAG., 1913, p. 239.

2. The sections 500 miles away in the north of Auckland are again quoted as explanatory of the supposedly misleading nature of the well-known clear section at the Waipara. I have just returned from a visit to these localities, and find that the sections represent inferences only, for in the one case (Kaipara) the section is obliterated by completely slipped ground for a distance of six chains, and in the other (Orewa) for ten chains. In both cases the stratigraphical break in the diagram is placed where the slipped ground is situated. At the Kaipara the original description distinguishes the strata as Jurassic and Upper Tertiary respectively. At Orewa the strata on the two sides of the slipped ground are not fossiliferous, and in the original description neither of them was assigned to any particular geological age.

3. Hutton's stratigraphical break between the two limestones is in Professor Park's article adopted as the plane that separates the Cretaceous from the Tertiary rocks. In 1904 the same author, in a critical description of this district traversing Hutton's work, states in his conclusion (ii) "That the Weka Pass Stone is conformable to the Amuri Limestone". And in his résumé (*m*) "The Weka Pass Stone is always conformable to the Amuri Limestone". He now states that previous to 1912 he had not critically examined the surface of the Amuri Limestone. Surely it is remarkable to make the statements quoted above entirely contradictory of Hutton's work without critically examining the surface upon the nature of which Hutton relied, though it must have been seen. One of his sections in the paper referred to actually represents his view of Hutton's typical exposure. An author who works thus can hardly be taken seriously.

4. May I add a word of personal explanation. Twenty years ago I graduated from the instruction of my revered teacher, the late Captain Hutton, F.R.S. Impressed by his wide erudition and by his capacity for work, I naturally accepted without question his views on New Zealand stratigraphy. To these I clung for many years, and tried to apply them to those districts where I was at work. Difficulties, however, multiplied and in time became insuperable. I finally went to Hutton's typical localities in the confident expectation that information gained there would solve my difficulties. Surprise and regret were great when I found that, in my opinion, the stratigraphical facts had been represented erroneously by my old teacher. The so-called Cretaceo-Tertiary theory never had any attraction for me. Hard facts in field work have compelled me to accept a series of sediments continuously deposited, rising from beds with Cretaceous fossils to others with younger Cainozoic fossils. This was in opposition to my fondest expectations.

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University of Otago,
Dunedin, N.Z.
April 4, 1913.